Teaching Scheme	Examination Scheme
Lectures : 02 Hrs./week	Term Test : 15 Marks
Tutorial : NIL	Teacher Assessment: 20 Marks
Credit : 02	End Sem Exam : 65 Marks
	Total Marks : 100 Marks

Course Objectives

1. To provide a coherent development to the students for the courses in sector of Engineering like Transportation Engineering
2. To present the foundations of many basic Engineering tools and concepts related Highway Engineering
3. To provide a coherent development to the students for the courses in sector of Railway Engineering
4. To understand the basics involved in the crossing and turnout of railway track.
5. To understand the Civil engineering aspects of Highway and Railway Engineering.

Cos	Course Outcomes	Blooms Level	Blooms Description
CO1	The students will gain an experience in the implementation of Transportation Engineering on engineering concepts which are applied in field Highway Engineering	3	Apply
CO2	The students will learn to understand the theoretical and practical aspects of highway engineering along with the design and management applications	4	Analyzing
CO3	The students will learn to design the pavements by considering various aspects associated with traffic safety measures	3	Apply
CO4	Know about the basics and design of various components of railway engineering	2 2	Understand Understand
CO5	Understand the types and functions of tracks, junctions and railway stations.	3 4	Apply Analyzing

Unit- I Introduction to Highway Engineering

- a. Highway Planning and Development: Highway planning in India, development, rural and urban roads, road, departments in India, road classification, road authorities i.e. IRC, CRRI, NHAI, etc., Financing of road projects, road safety audit.
- b. Field Surveys: Reconnaissance, aerial surveys, location surveys, location of bridges. Highway alignment: Basic requirements of an ideal alignment and factors controlling it, special requirements for hill roads. C. Highway Geometric Design: Topography and physical features, cross section elements like carriageway width, formation width, right of way, etc., friction, Light reflecting characteristics, roughness, camber, sight distances, horizontal alignment, design speed, super-elevation, transition curve, gradients

Unit 1

HSP

Overview

- From the beginning of history, human sensitivity has revealed an urge for mobility leading to a measure of Society's progress.
- The history of this mobility or transport is the history of civilization. For any country to develop with right momentum modern and efficient Transport as a basic infrastructure is a must.
- Transport (British English) or transportation (American English) is the movement of people and goods from one place to another. The term is derived from the Latin trans ("across") and portare ("to carry").

1.2 Means of Transport

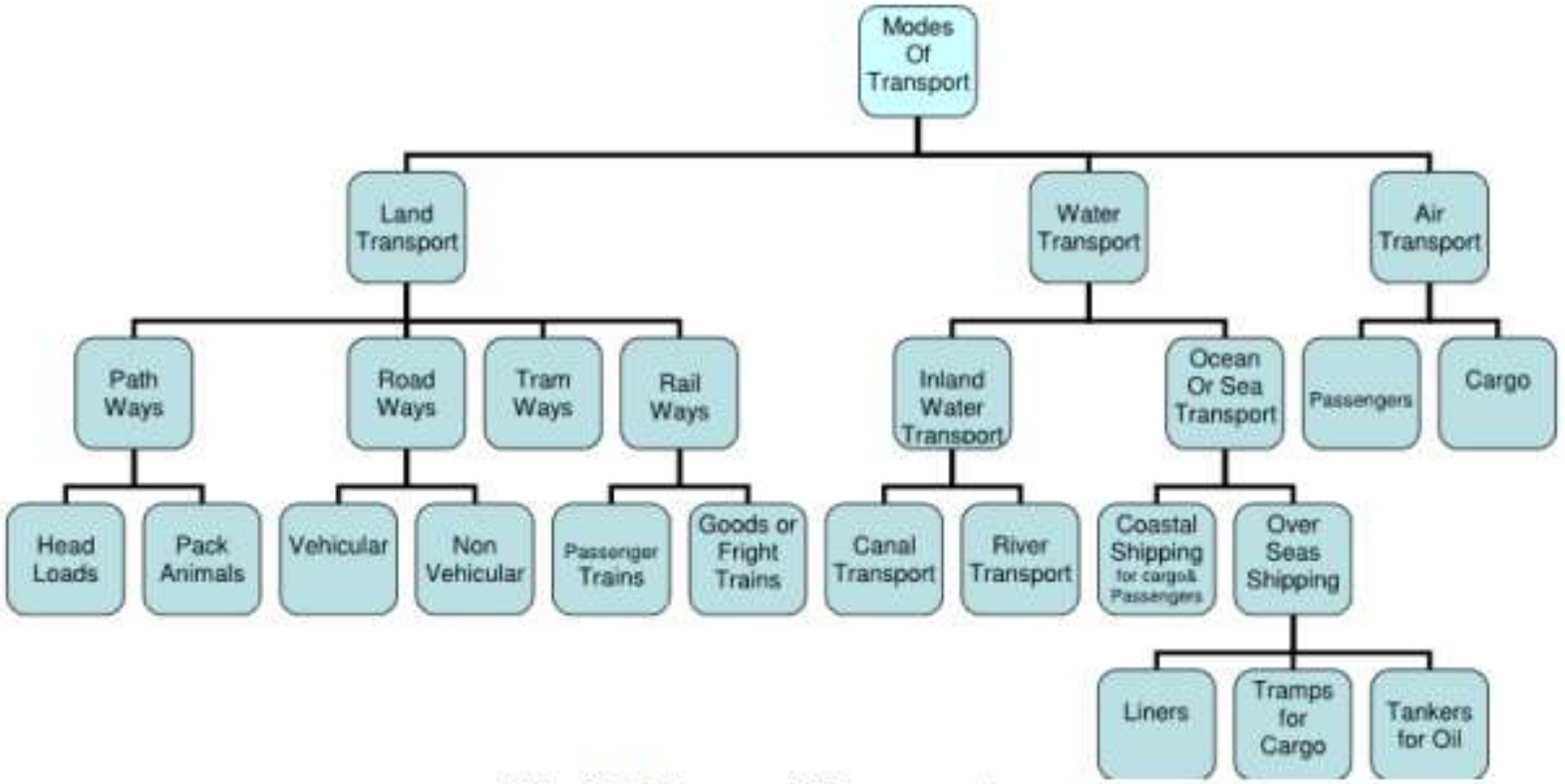


Fig.1.1 Means of Transport

Advantage and Disadvantage Different Modes of Transport

(A) Road Transport

Advantages	Disadvantages
1. Less Capital Outlay 2. Door to Door Service 3. Service in Rural Areas 4. Flexible Service 5. Suitable for Short Distance 6. Lesser Risk of Damage in Transit 7. Saving in Packing Cost 8. Rapid Speed 9. Less Cost	1. Seasonal Nature 2. Accidents and Breakdowns 3. Unsuitable for Long Distance and Bulky Traffic 4. Slow Speed 5. Lack of Organisation
10. Private Owned Vehicles 11. Feeder to other Modes of Transport	

(B) **Railway Transport**

Advantages	Disadvantages
1. Dependable	1. Huge Capital Outlay
2. Better Organised	2. Lack of Flexibility
3. High Speed over Long Distances	3. Lack of Door to Door Service
4. Suitable for Bulky and Heavy Goods	4. Monopoly
5. Cheaper Transport	5. Unsuitable for Short Distance and Small Loads
6. Safety	6. Booking Formalities
7. Larger Capacity	7. No Rural Service
8. Public Welfare	8. Under-utilised Capacity
9. Administrative Facilities of Government	9. Centralised Administration
10. Employment Opportunities	

(C) Air Transport

Advantages	Disadvantages
1. High Speed	1. Very Costly
2. Comfortable and Quick Services	2. Small Carrying Capacity
3. No Investment in Construction of Track	3. Uncertain and Unreliable
4. No Physical Barriers	4. Breakdowns and Accidents
5. Easy Access	5. Large Investment
6. Emergency Services	6. Specialised Skill
7. Quick Clearance	7. Unsuitable for Cheap and Bulky Goods
8. Most Suitable for Carrying Light Goods of High Value	8. Legal Restrictions
9. National Defence	
10. Space Exploration	

Elements of transport

- a) Vehicle or carrier to carry passenger or goods
- b) Route or path for movement of carriers
- c) Terminal facilities for loading and unloading of goods and passengers from carriers
- d) Prime Mover
- e) Transit time and cost
- f) Cargo

Major disciplines of transportation

- 1. Transportation Planning
- 2. Geometric Design
- 3. Pavement Design
- 4. Traffic Engineering

Historical Development of Road Construction Roman Roads

- Mesopotamia Civilization – 3500 BC
- Romans were pioneers in road construction – Still in existence after 2000 years
- Main features:

– Built in straight lines regardless of gradient

– Built after soft soil was removed

– Total thickness was 0.75 – 1.2 meters

– Typical cross-section

Historical Development of Road Construction
Roman Roads

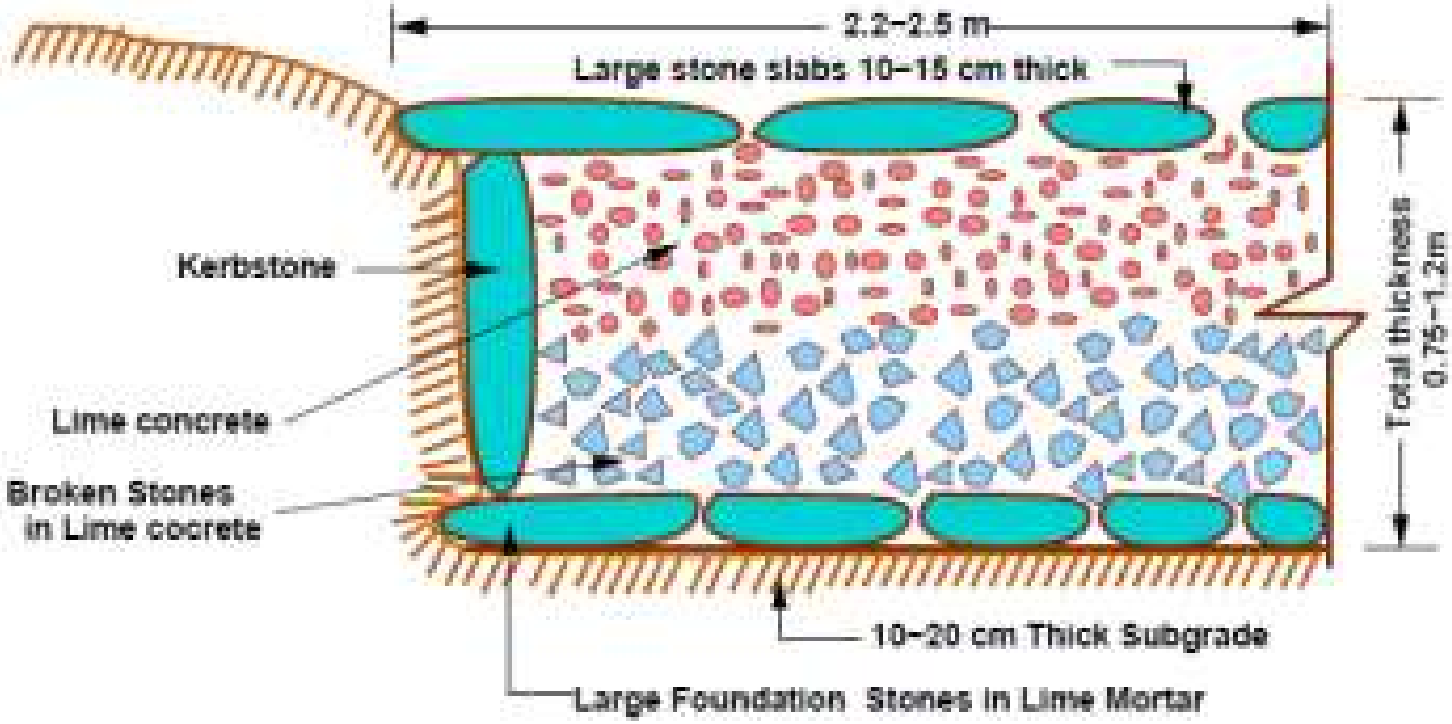


Figure 2:1: Roman roads

Historical Development of Road Construction French Roads

- Pierre Tresaguet (1716-1796)
- Implemented in 1775 AD
- Features:
  - Sub-grade was prepared and large foundation stones laid
  - Top wearing course – smaller stones
  - Shoulders were provided

Historical Development of Road Construction
French Roads

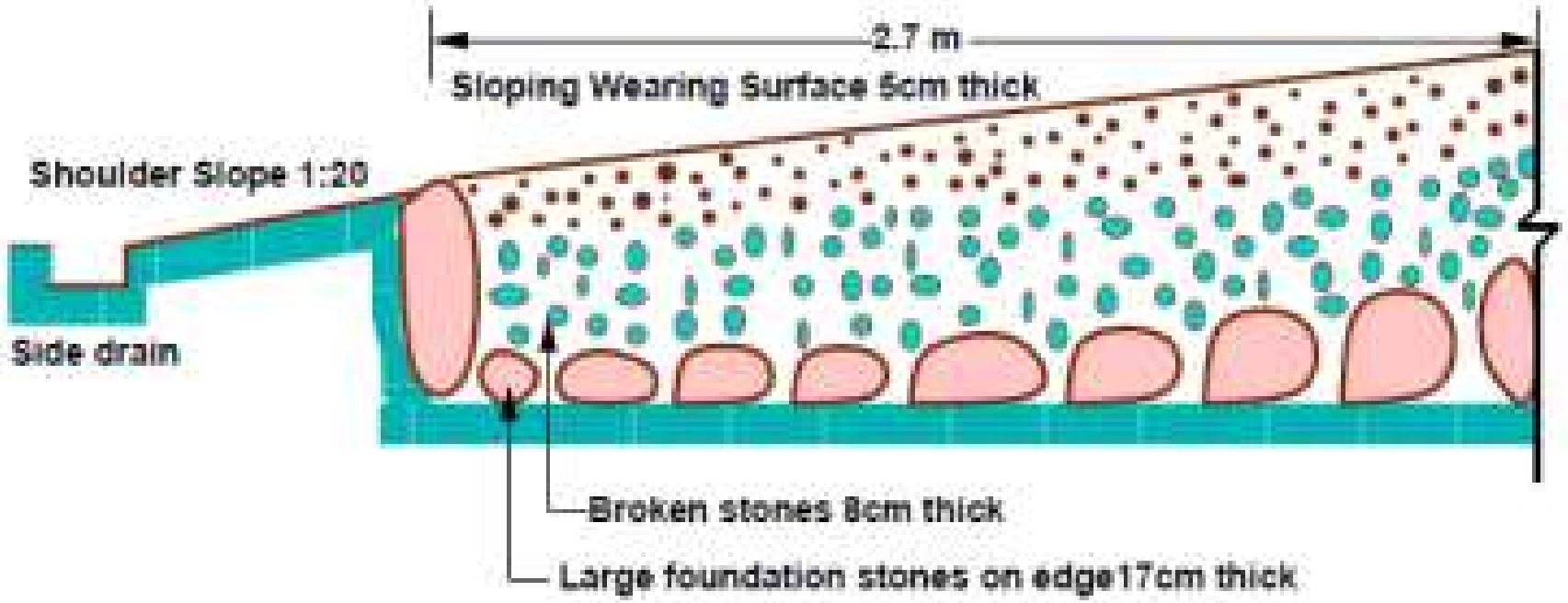


Figure 2:2: French roads

Historical Development of Road Construction British Roads

- John Macadam (1756- 1836), Surveyor Gen. of England
- Became popular in 1827 AD, Scientific method
- Main features:
  - Sub-grade drainage and compaction – cross slope 1 in 36
  - First person to suggest that heavy foundation stones are not required
  - Compacted layer of smaller broken stones at bottom. Better dispersion of load
  - Pavement surface cross-slope was 1 in 36

Historical Development of Road Construction
British Roads

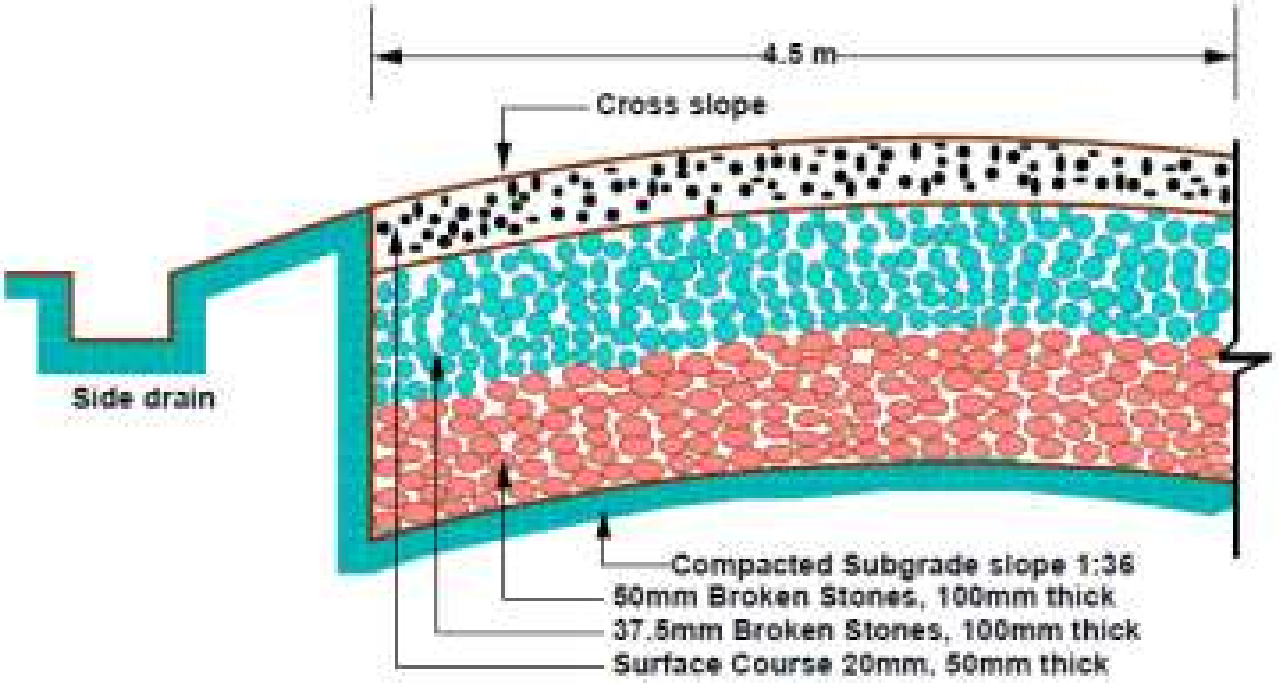


Figure 2:3: British roads

Necessity for Highway Planning

- Planning is prerequisite for any development program
- Planning is of great importance when funds are limited
- Best utilization is very much needed

    - Main object of highway planning:
        - To plan road network for efficient and safe traffic operations at minimum cost
        - Minimize construction and maintenance
        - Arrive at road systems of different categories to maximize utility
        - Derive precise project plan with timeline and priorities
        - Proper phasing of project
        - To plan for the future
        - To work out financing options (public, private, public-private)

History of Road Development in India

- Ancient Period (3500 BC)
- Mughul Period (15th Century)
- British Period (17th & 18th Century)
- Free India (1950 onwards)

Types of Ancient Indian Roads

- Indus Valley Civilization :
  - Roads with brick drains on both sides.
- Mauryan rule in the 4th century constructed
  - Rajpath (high roads)
  - Banikpaths (merchant roads).
- Ashoka Regime:
  - Road networks with horticulture and rest houses at 4.8 – 6.4km along the roads.
- Mughul Period
  - Trunk roads between Northwest to Eastern part and also linking coastal and central part of India
- British Period
  - Trunk roads, bridges, PWD was formed, construction of Grand Trunk Road

Highway Development Plant : Jaykar Committee -1927

- The Jayakar Committee, officially known as the Indian Road Development Committee, was formed in 1927 under the chairmanship of Sir M. R. Jayakar. This committee played a crucial role in shaping the development of roads and highways in India. Here are the key highlights of the Jayakar Committee's recommendations and impact:
- **Background**
- **Formation**: The committee was constituted to address the inadequate and poor condition of roads in India during the British colonial period.
- **Chairman**: Sir M. R. Jayakar, an eminent Indian lawyer and politician.

Jaykar Committee -1927 *Recommendations*

- **Central Road Fund (CRF)**:
  - **Introduction**: The committee recommended the establishment of a dedicated road fund, known as the Central Road Fund (CRF), financed by an additional tax on petrol.
  - **Purpose**: This fund was to be used exclusively for the development and maintenance of roads.
- **Indian Roads Congress (IRC)**:
  - **Formation**: The committee recommended the creation of a central organization to coordinate road development activities.
  - **Impact**: The Indian Roads Congress (IRC) was established in 1934, serving as a premier technical body that sets standards and guidelines for road construction and maintenance in India.
- **Road Classification**:
  - **Categories**: Roads were to be classified into various categories based on their importance and usage, such as national highways, state highways, and district roads.
  - **Standards**: Establishment of uniform standards for road construction and maintenance across different categories.
- **Technical Training**:
  - **Focus on Education**: Emphasized the need for technical education and training of engineers and road construction workers.
  - **Institutes**: Recommended the establishment of institutions for research and training in road engineering and construction.
- **Improved Road Construction Techniques**:
  - **Modern Methods**: Advocated for the adoption of modern road construction techniques and materials to improve the quality and durability of roads.

Jaykar Committee -1927

Impact

- **Institutional Framework**: The establishment of the Central Road Fund and the Indian Roads Congress created a robust institutional framework for road development in India.
- **Funding Mechanism**: The CRF provided a steady and reliable source of funding for road construction and maintenance.
- **Standardization**: The recommendations led to the standardization of road construction practices and the introduction of scientific methods in road engineering.
- **Infrastructure Development**: The committee's recommendations laid the foundation for systematic and planned road development in India, significantly improving the country's road infrastructure over time.

First 20-Year Road Development Plan (Nagpur Plan: 1943-1963)

- **Objective**: To develop a road network that would connect all major cities, towns, and rural areas.
- **Targets**: Development of 16 km of road length per 100 square km of area.
- **Classification of roads** : National Highways, State Highways, Major District Roads, and Village Roads.
- **Outcomes:**

1.Foundation for systematic road development

2.Emphasis on connecting remote and rural areas to urban centers.

Second 20-Year Road Development Plan (Bombay Plan: 1961-1981)

- **Objective**: To build upon the achievements of the Nagpur Plan and further expand the road network.
- **Targets**:
- Increase road density to 32 km per 100 square km of area.
- Focus on improving road quality and maintenance.
- Emphasis on connecting major economic centers.
- **Outcomes**:
- Expansion of National and State Highways.
- Improvement in road construction standards and practices.

Third 20-Year Road Development Plan (Lucknow Plan: 1981-2001)

- **Objective**: To modernize the road network and enhance connectivity.
- **Targets**:
- Increase road density to 82 km per 100 square km of area.
- Development of expressways and major arterial roads.
- Improvement in road safety and maintenance.
- **Outcomes**:
- Introduction of expressways.
- Significant improvement in road infrastructure.
- Increased focus on road safety measures.

Fourth 20-Year Road Development Plan (Vision 2021: 2001-2021)

- **Objective**: To create a world-class road infrastructure in India.
- **Targets**:
- Development of the National Highways Development Project (NHDP).
- Creation of a Golden Quadrilateral connecting Delhi, Mumbai, Chennai, and Kolkata.
- Development of the North-South and East-West Corridors.
- Rural road connectivity under the Pradhan Mantri Gram Sadak Yojana (PMGSY).
- **Outcomes**:
- Successful completion of the Golden Quadrilateral.
- Enhanced connectivity between major cities and economic hubs.
- Improved rural road connectivity, reducing travel time and boosting rural economies.

total target lengths for vision 2021:

a. The main highway network

15,766 km of expressways (Target length)

80,000 km (target length) of national highways; 57,700 km (Achieved length)

b. Secondary road network:

1,60,000 km (target length) of State Highways; 1,24,300 km (Achieved length)

3,20,000 km (target length) of major district roads; 29,94,000 km (Achieved length)

Other District Roads and Village Roads: 29,94,000 km (achieved length), no objective set.

Current and Future Plans (Post-2021)

•**Bharatmala Pariyojana**:
•Objective: To optimize the efficiency of freight and passenger movement across the country by bridging critical infrastructure gaps.
•Focus Areas: Development of economic corridors, inter-corridor and feeder routes, border and international connectivity roads, coastal and port connectivity roads, and greenfield expressways.
•**Green Highways Policy**:
•Objective: To promote the greening of highway corridors with a focus on environmental sustainability.
•Initiatives: Plantation along highways, use of recycled materials in road construction, and adoption of eco-friendly technologies.
•**Smart Roads and ITS (Intelligent Transportation Systems)**:
•Objective: To integrate technology with road infrastructure for better traffic management, safety, and efficiency.
•Initiatives: Deployment of smart traffic signals, automated toll collection, real-time traffic monitoring, and incident management systems.
•**Sustainable and Resilient Infrastructure**:
•Objective: To build resilient road infrastructure that can withstand natural disasters and climate change impacts.
•Initiatives: Adoption of sustainable construction practices, use of resilient materials, and incorporation of disaster risk reduction measures in road planning and design.

Classification of Roads

- Classification based on weather:
  - All weather roads (roads which are negotiable during all weathers)
  - Fair-weather roads
- Based on the carriage way:
  - Paved
    - Surfaced
    - Un-surfaced
  - Unpaved

Classification of Roads

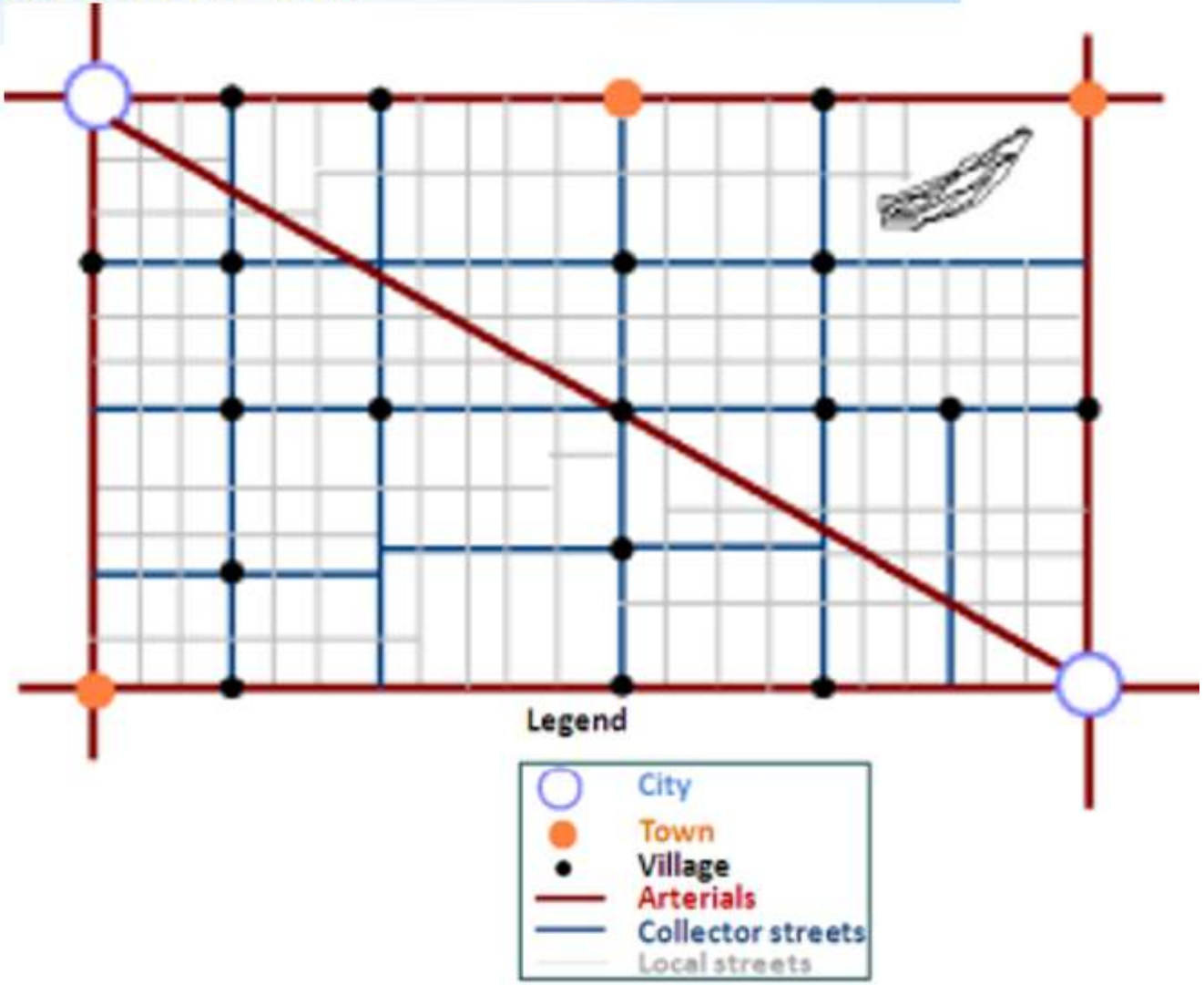
- Methods of classification of roads:
  - Traffic volume (arbitrary)
    - Heavy, medium, light traffic roads
  - Load transported or tonnage
    - Class I, II, etc or Class A, Class B
  - Location and function (Nagpur)
    - National Highways
    - State Highways
    - Major District Roads (MDR)
    - Other District Roads (ODR)
    - Village Roads

Based on modified system of Highway classification

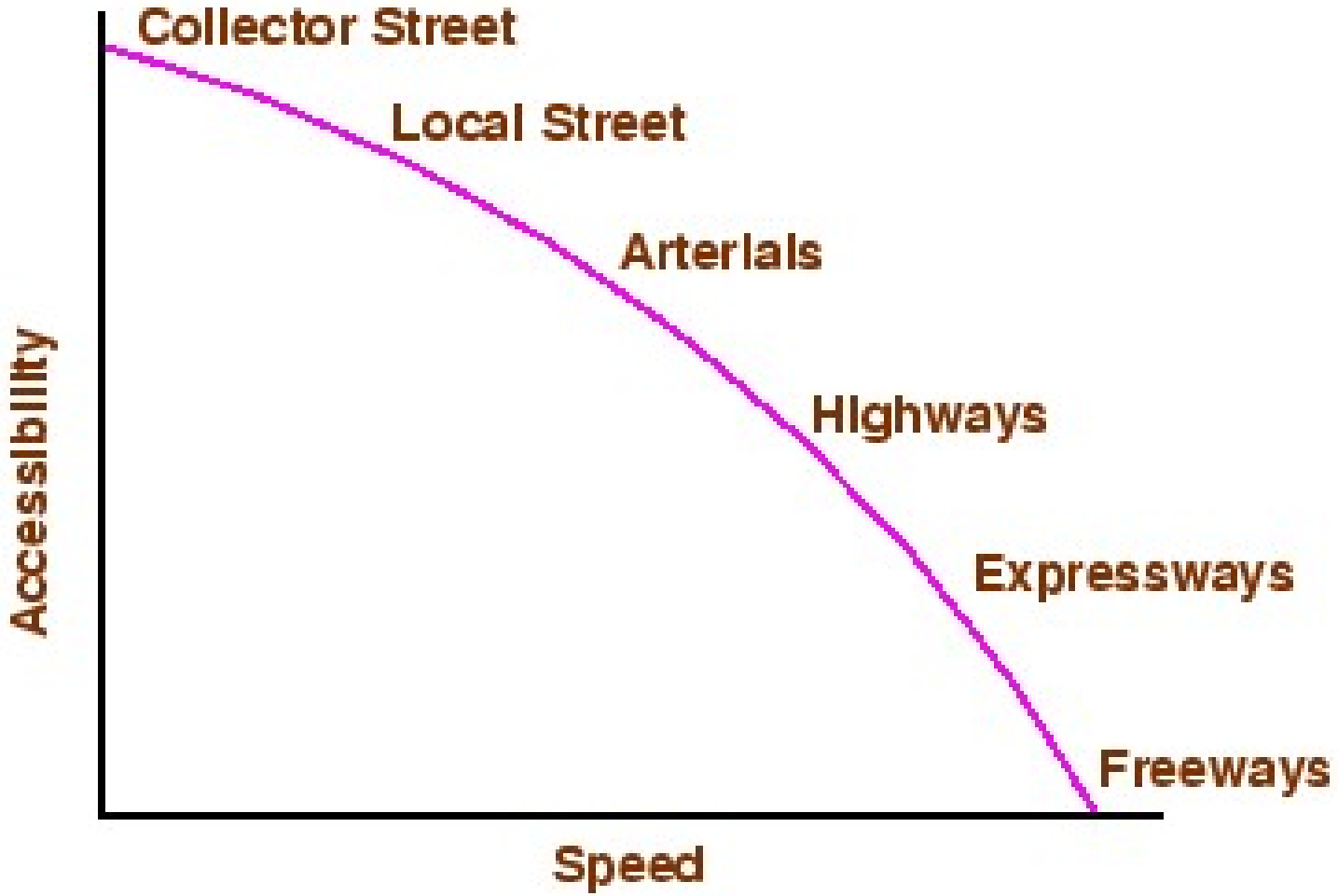
- Primary
  - Expressways
  - National Highways
- Secondary
  - SH
  - MDR
- Tertiary
  - ODR
  - VR

Urban Road Classification

- ARTERIAL ROADS
- SUB ARTERIAL
- COLECTOR
- LOCAL STREET
- CUL-DE-SAC
- PATHWAY
- DRIVEWAY



Speed vs accessibility



Arterial Streets

- Design Speed: 80 km/hr.
- Land width= 50-60 m.

Sub-Arterial Streets

- Busstops but no standing vehicle.
- Design Speed: 60 Km/hr.
- Land width= 30-40 m.

Collector Streets

- Design Speed: 50 km/hr.
- Land width= 20-30 m.

Local Streets

- Design Speed: 30 km/hr.
- Land width= 10-20 m.

Classification of Roads

- National Highways (NH)
  - Length and breadth of India, connecting ports, foreign highways, capitals, large states
- State Highways
  - Arterial roads of state, connecting up with NH, Dist HQs and important cities
- Major District Roads
  - Important roads within district, connect production and markets, lower speed
- Other District Roads
  - Serving rural areas of production and markets, taluk HQs
- Village Roads
  - Connecting villages or groups of villages with nearest road

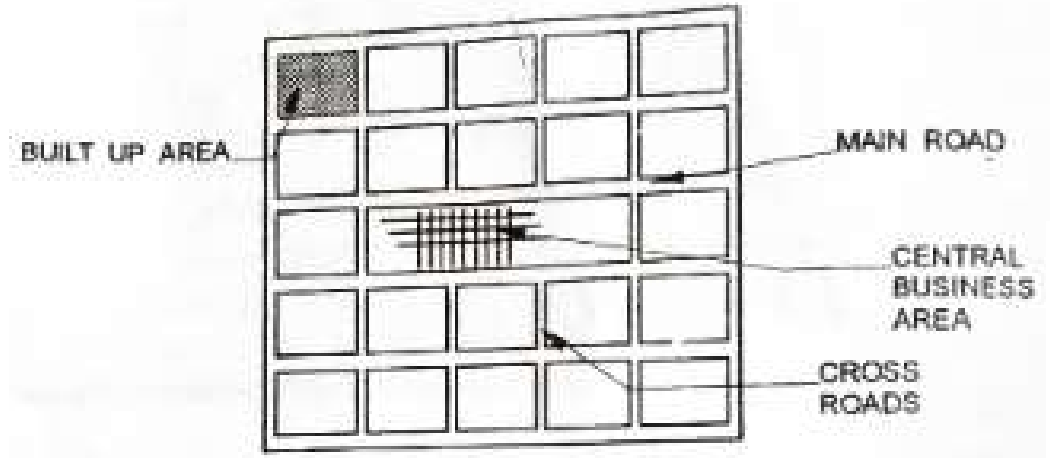
Road Network Patterns

- Rectangular or Block patterns
- Radial or Star block pattern
- Radial or Star Circular pattern
- Radial or Star grid pattern
- Hexagonal Pattern
- Minimum travel Pattern

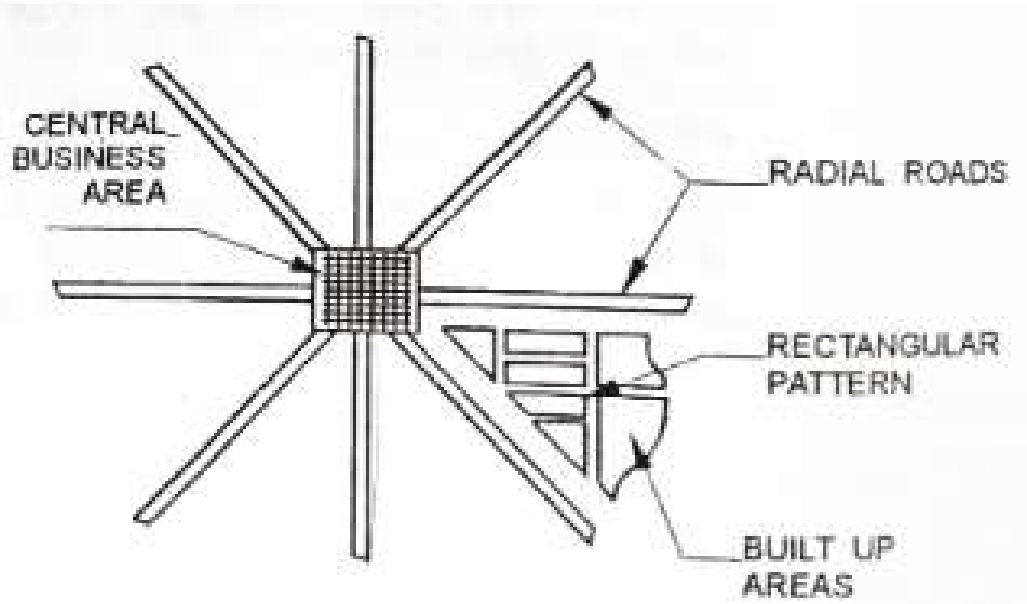
1. Grid Pattern

- **Description**: Roads are arranged in a perpendicular grid, forming rectangular blocks.
- **Advantages**:
- Easy navigation and orientation.
- Efficient land use.
- Flexibility in traffic distribution.
- **Disadvantages**:
- High number of intersections can lead to congestion.
- Not ideal for hilly terrains.
- **Examples**:
- Manhattan, New York City.
- Chandigarh, India.

Road Network Patterns



(a) Rectangular or block pattern



(c) Radial or star and block pattern

2. Radial Pattern

- **Description**: Roads radiate outward from a central point, often a city center or a major intersection.
- **Advantages**:
- Direct routes to the center.
- Efficient for centralized cities.
- **Disadvantages**:
- Can lead to congestion at the center.
- Limited flexibility for expansion.
- **Examples**:
- Paris, France.
- New Delhi, India

Rectangular or Block pattern

- In this pattern, the streets are usually of equal width and they cross at right angles.
- It is also known as Grid- Iron, or chequer- Board Pattern.
- This pattern is **suitable for flat country without any predominant natural feature.**
- The **example of this system are Philadelphia and Jaipur**

3. Linear Pattern

- **Description**: Roads follow a linear path, typically found along rivers, valleys, or coastlines.
- **Advantages**:
- Simple and straightforward navigation.
- Suitable for areas with natural constraints.
- **Disadvantages**:
- Limited cross-connections.
- Can lead to congestion on the main route.
- **Examples**:
- Mumbai, India (partially linear along the coastline).
- Coastal towns and cities

4. Radial and Circular Pattern

- **Description**: Combines radial roads with concentric circular roads, creating a series of rings connected by radial spokes.
- **Advantages**:
- Reduces congestion at the center.
- Provides multiple routes to a destination.
- **Disadvantages**:
- Complex layout.
- Can be costly to implement.
- **Examples**:
- Beijing, China.
- Moscow, Russia.

5. . Hierarchical Pattern

- **Description**: Roads are organized into a hierarchy of streets (arterial, collector, local).
- **Advantages**:
- Efficient traffic flow with designated functions for each road type.
- Reduced through-traffic in residential areas.
- **Disadvantages**:
- Can be confusing without clear signage.
- Potential bottlenecks at intersections of different road types.
- **Examples**:
- Suburban developments.
- Many modern planned cities.

6. Grid and Radial Hybrid Pattern

- **Description**: A combination of grid and radial patterns to optimize connectivity and distribution.
- **Advantages**:
- Balances ease of navigation and direct routes.
- Distributes traffic efficiently.
- **Disadvantages**:
- Complex planning and implementation.
- Can be challenging to adapt to existing urban areas.
- **Examples**:
- Washington, D.C., USA.

Rectangular or Block pattern

Advantages Of This Pattern

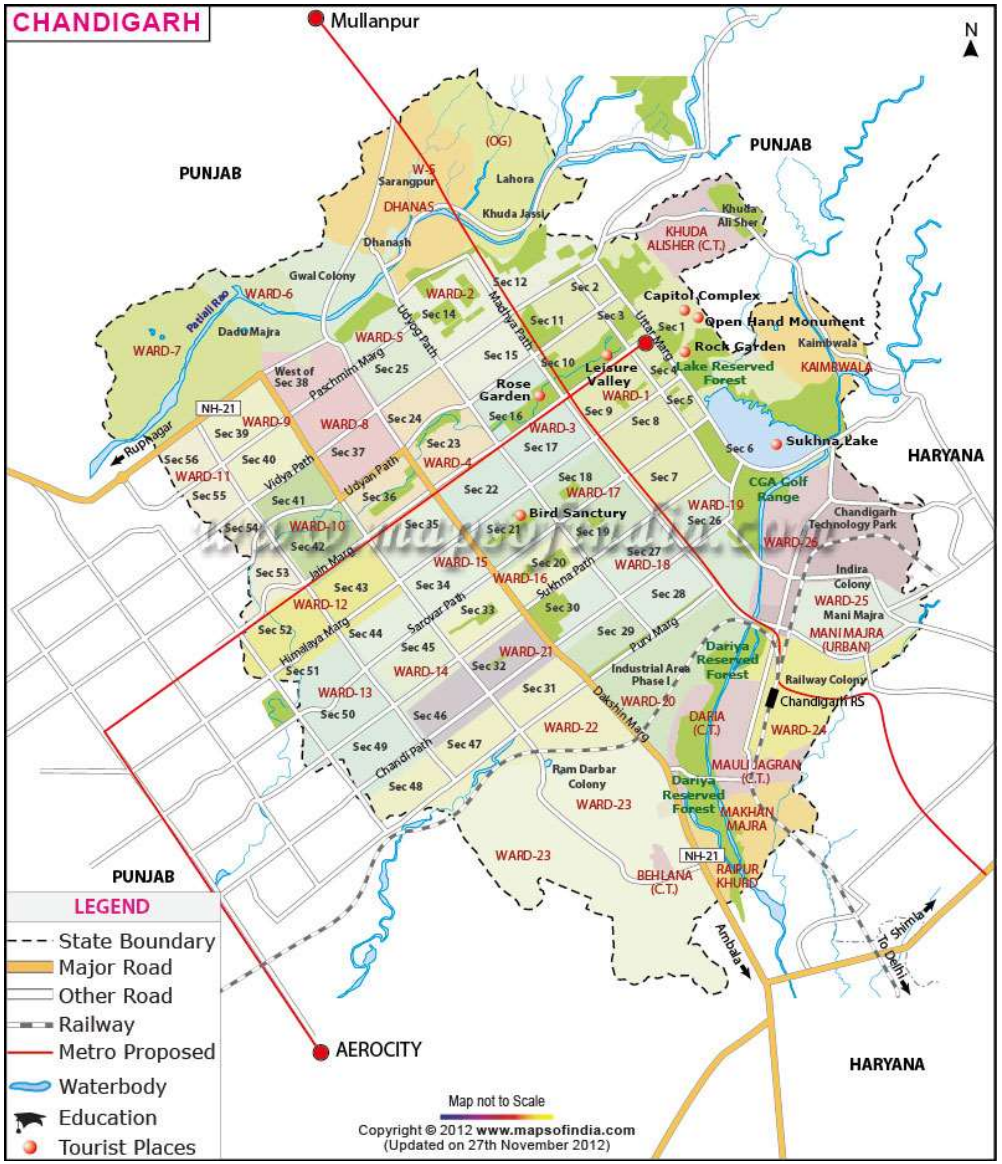
Parallel roads increases the traffic capacity.

- Grants comfort and convenience due to its regularity.
- Simple in nature.
- Economic construction.
- Wastage of land is Minimum

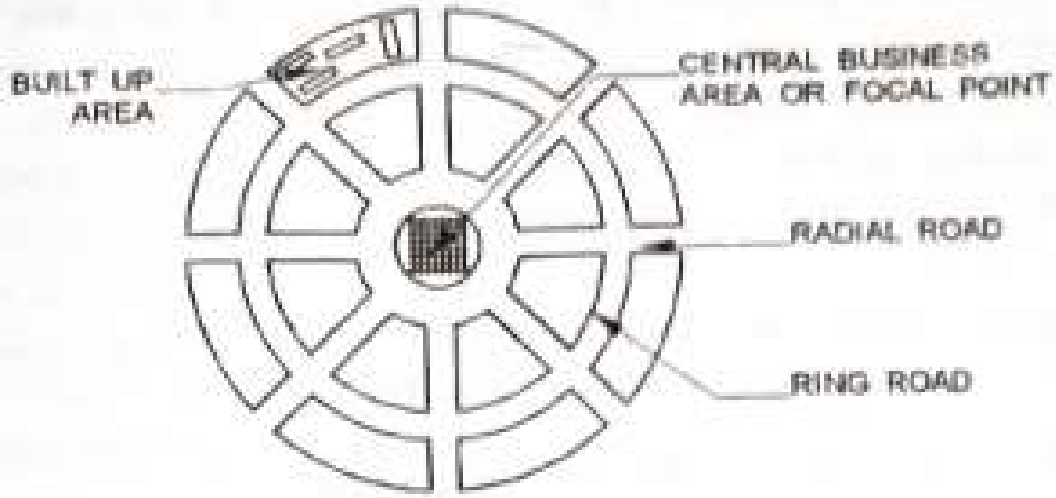
Disadvantages Of This Pattern

- As many intersections causes Road Accidents.
- On uneven topography, it leads to great inconvenience and discomfort.
- It is to mathematical and monotonous because the roads are straight and there is no variety.
- It requires more traffic signals

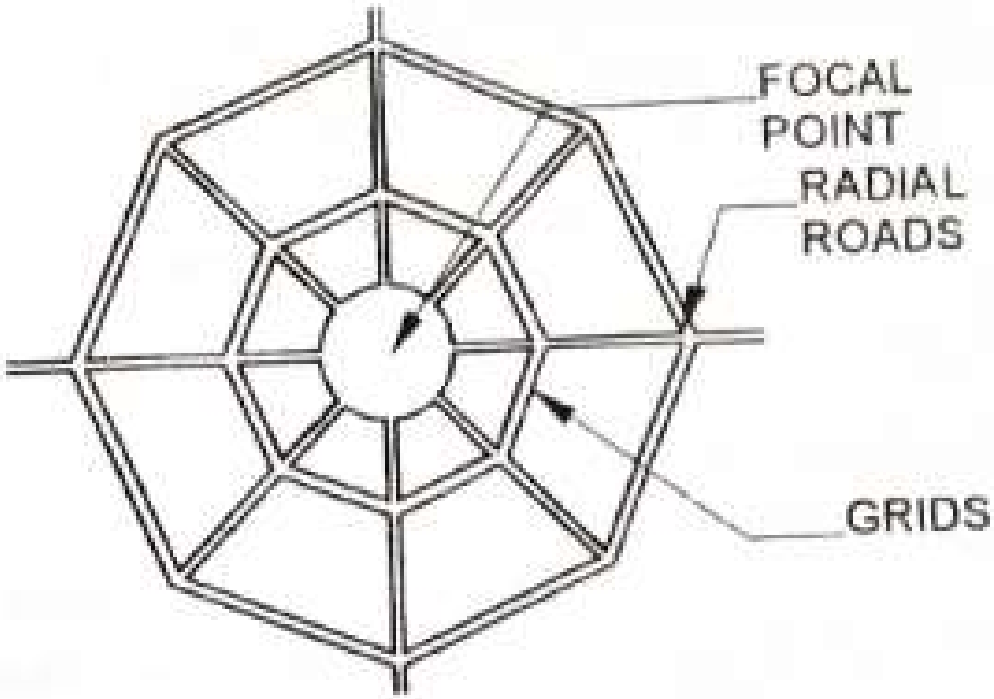
- The Block pattern has been adopted in the city roads of Chandigarh. But from traffic operation point this is not considered convenient.



Road Network Patterns

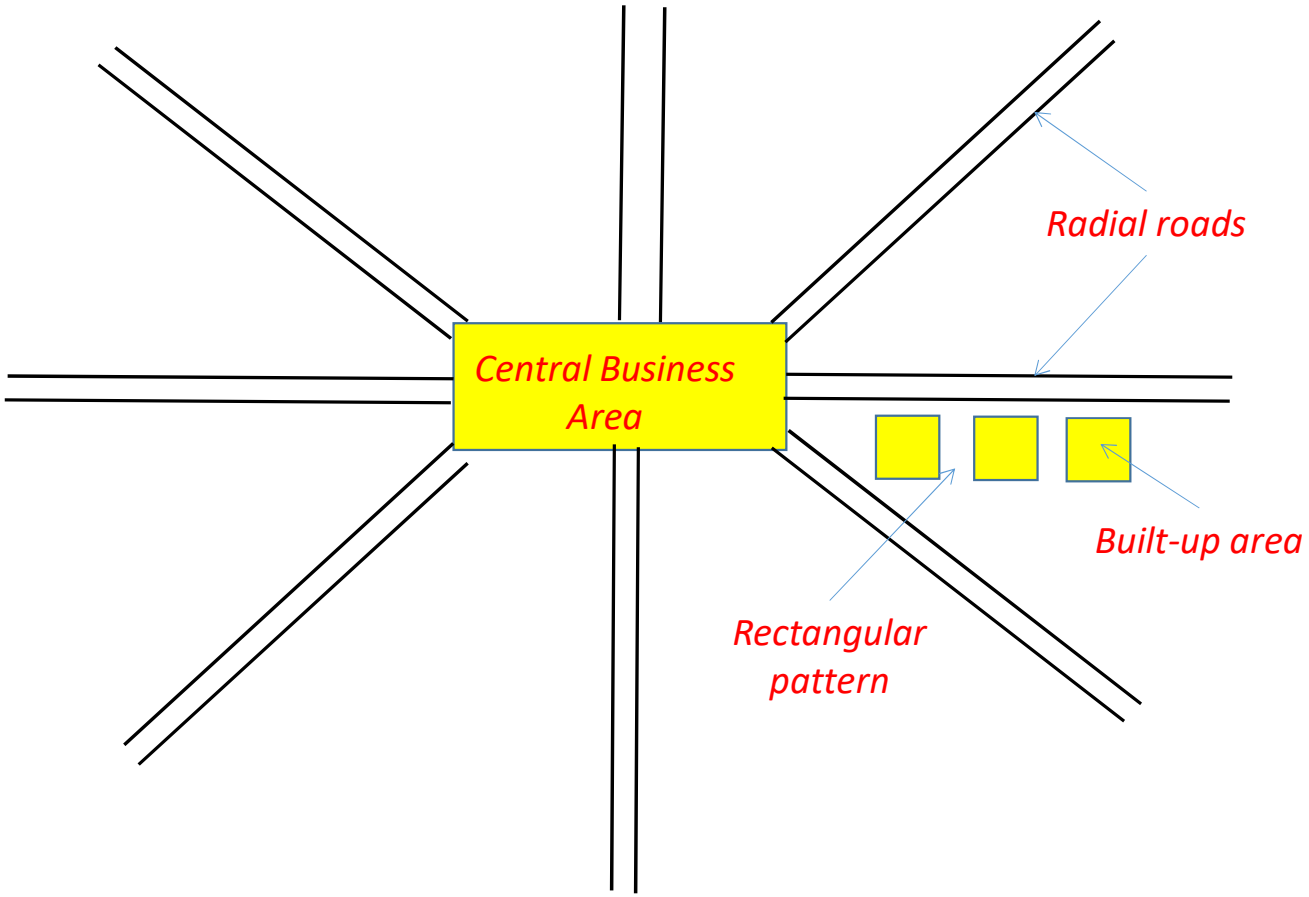


(d) Radial or star and circular pattern



(e) Radial or star and grid pattern

Radial or star & Block pattern



Radial or star & Block pattern

- This arrangement is an **improvement on Grid Iron Pattern.**
- The **diagonal Street Provides direct communication** between distant parts of the street.
- The **point where diagonals meet are utilized for park, garden, memorial etc, However, a dangerous intersection is formed at the crossing point of diagonal street and rectangular street**.

Radial or star & Block pattern

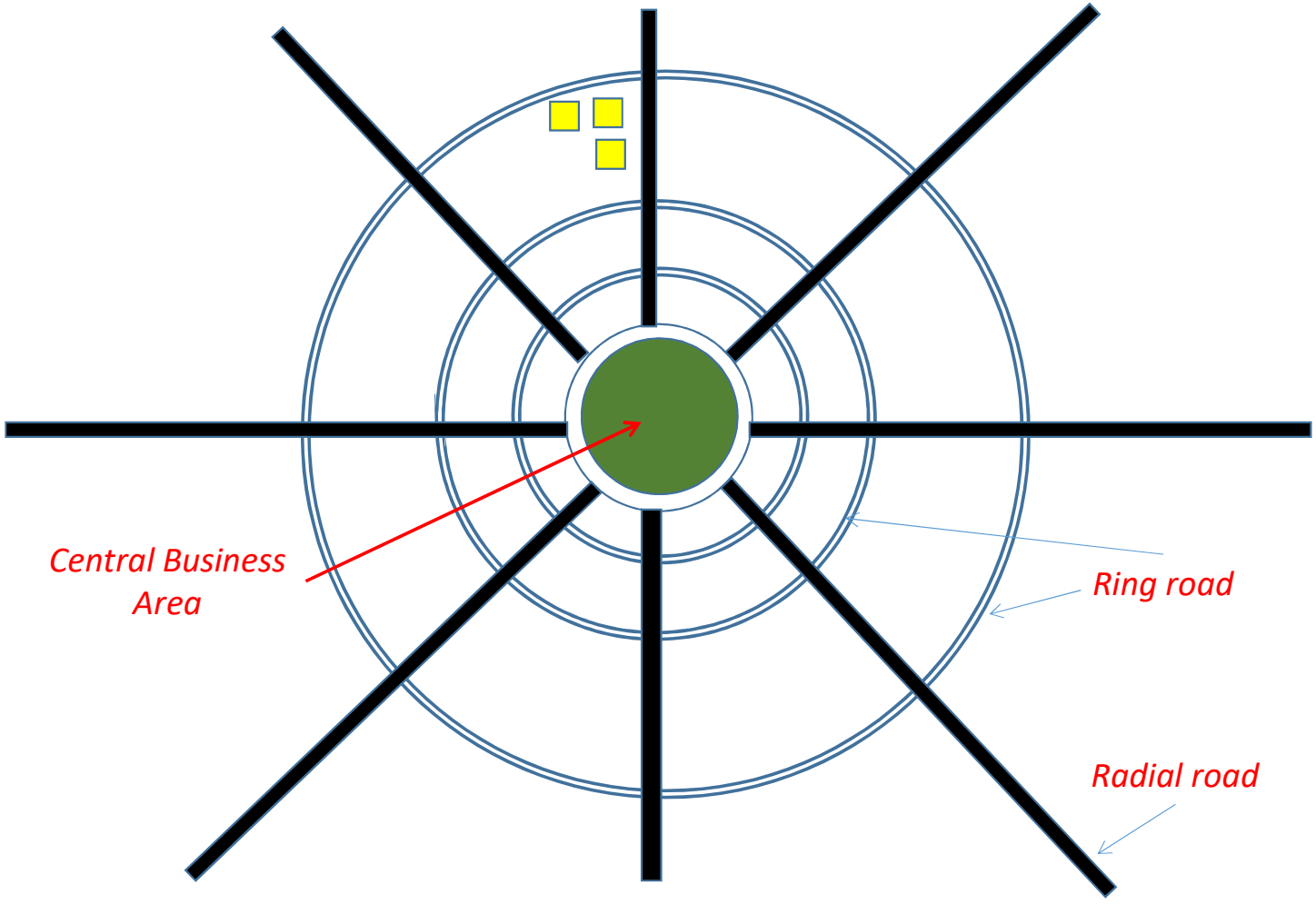
- utilized at sites for gorgeous statues, monuments and fountains.
- The public building are provided with enough open spaces all around them.
- The streets are very wide and are well planted with trees.

Radial or star & Block pattern

Before

After

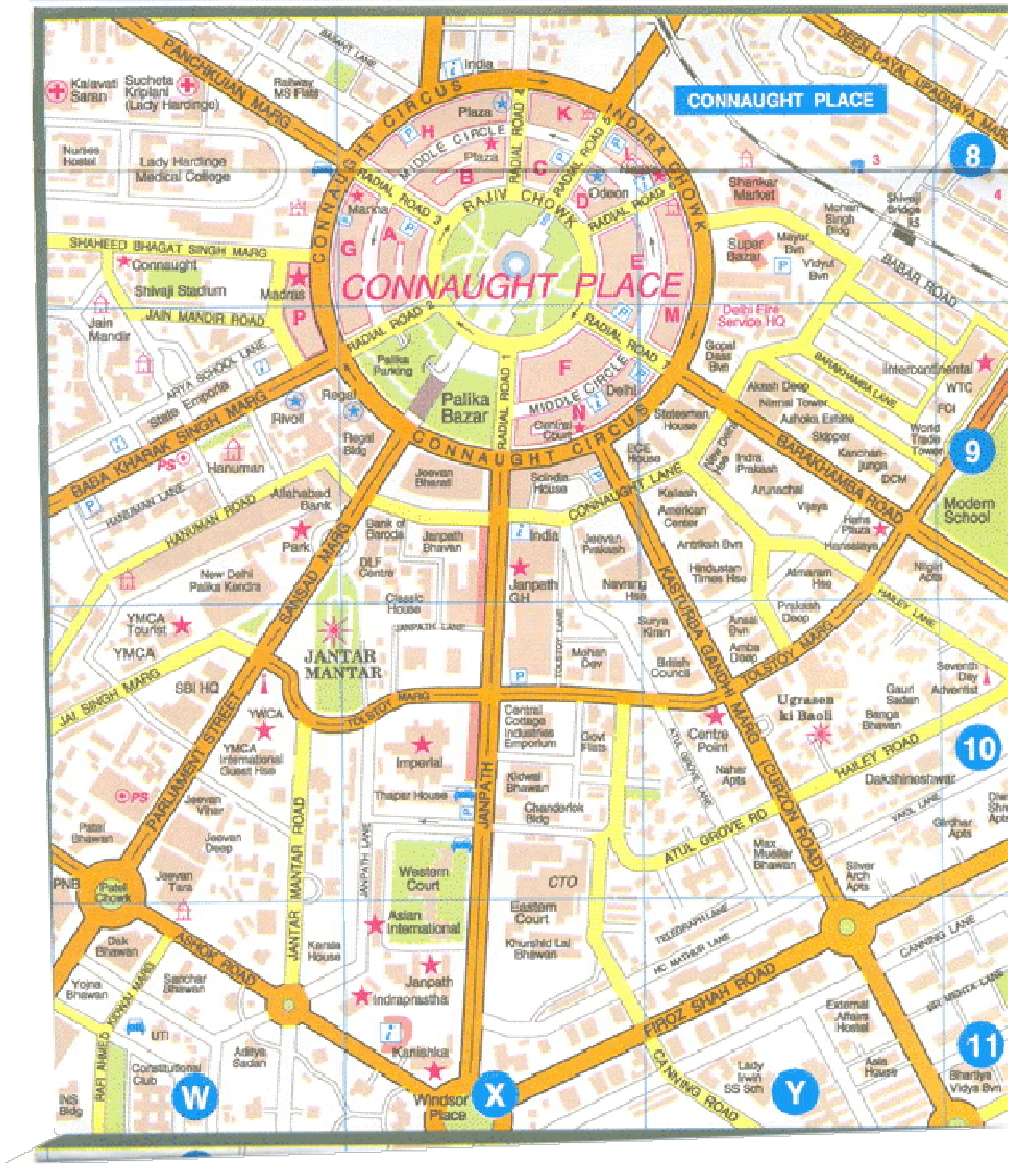
Radial or star & Circular pattern



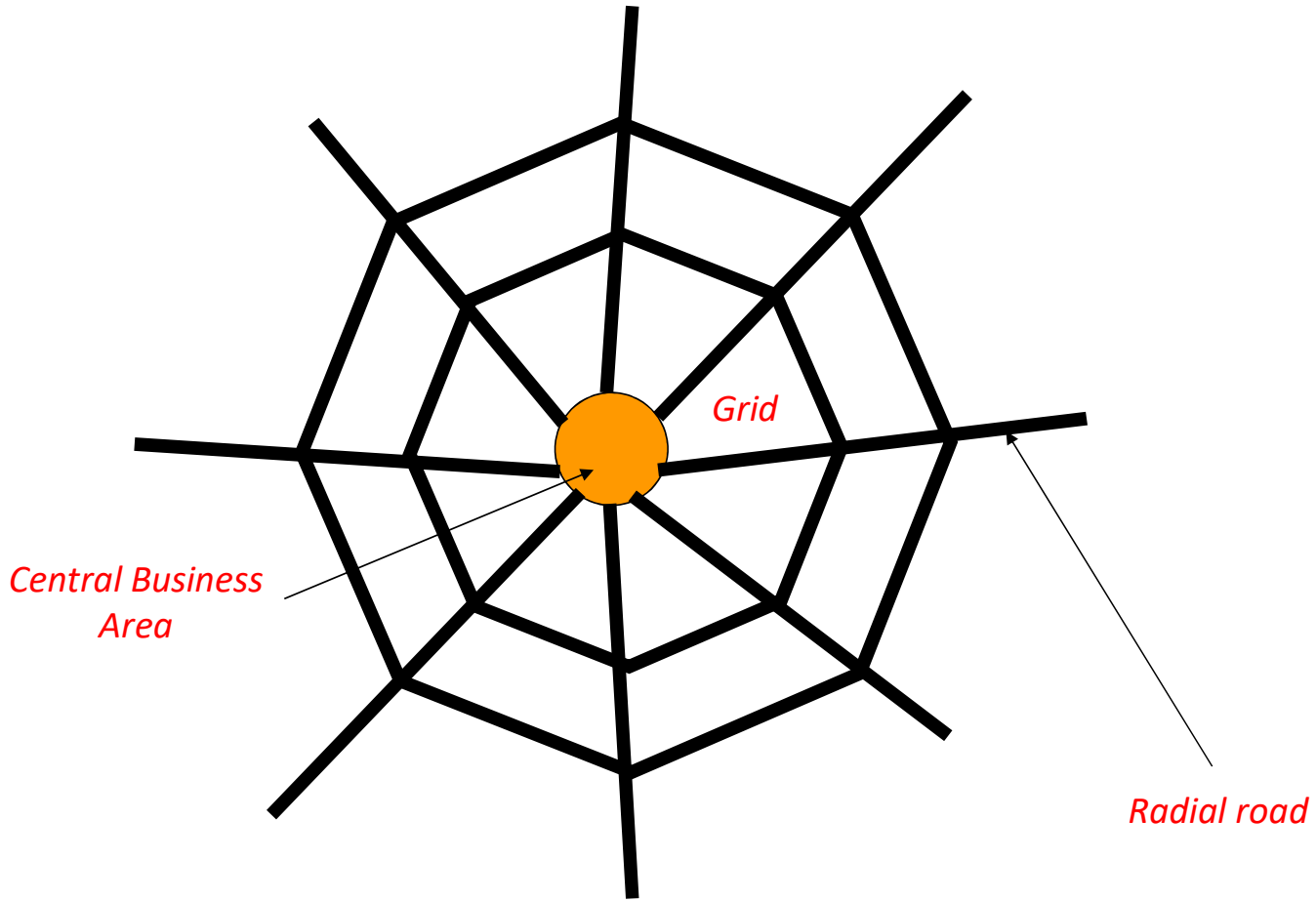
Radial or star & circular pattern

- In this system the **ring roads or circumferential roads are connected with radial roads.**
- This patter is **also known as Spider's Web System.**
- The **concentric ring is developed**
- However if the radial roads are not well developed the **central part they will overload at the central part of the town.**

An example of radial and circular pattern is the road network of Connaught Place in New Delhi



Radial or star & Grid pattern



RADIAL OR STAR & GRID PATTERN

- **contribute to systematic site planning and, consequently, deserves a closer look.**
- North-south movement becomes circuitous, indirect, and inconvenient,
- Example: Nagpur Plan formulae

RADIAL OR STAR & GRID PATTERN

Advantages:

1)Keep **vehicular traffic safe**

2) **Reduce cut-through** traffic

3) **Improve traffic flow** in both directions.

4) **Improve land use** efficiency and unit density.

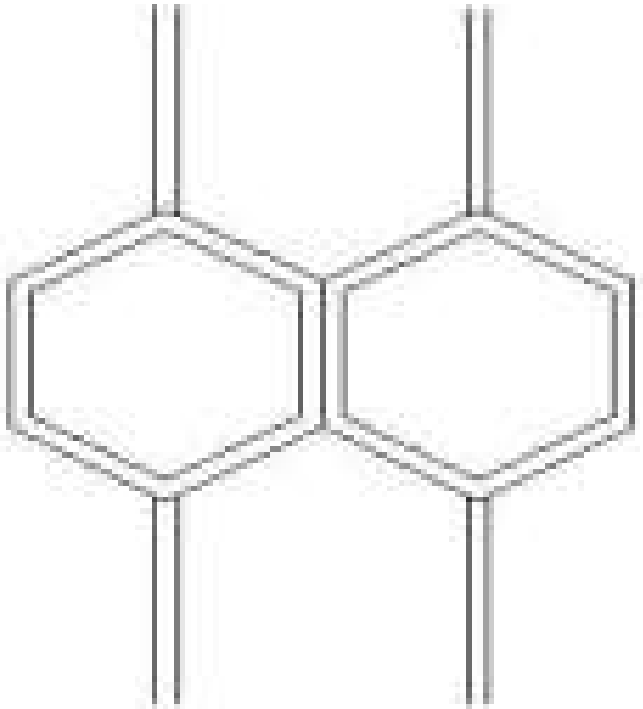
Limitations:

1)Islands separating the **approach and exit lanes**, known as splitter islands, **should extend far enough**.

2)Traffic signs, pavement markings, and lighting should be More.

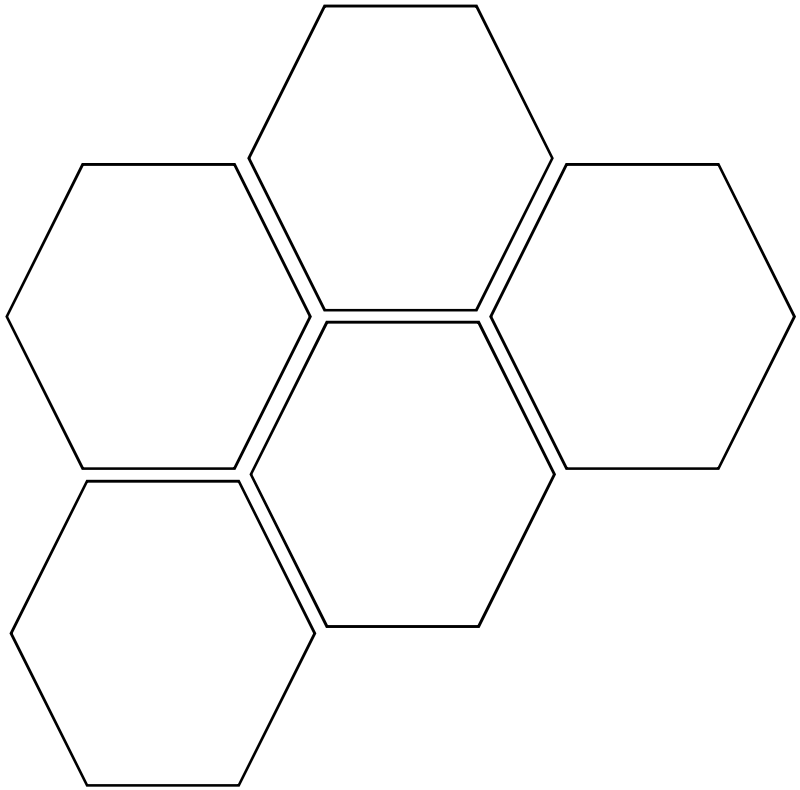
An example of radial and Grid pattern is the road network of Chennai.

Road Network Patterns



Hexagonal Pattern

Hexagonal pattern



HEXAGONAL PATTERN

- In this pattern, the entire area is **provided with a network of roads formatting hexagonal figures.**
- At each corner of the hexagon, **three roads meet the built-up area boundary by the sides of the hexagons is further divided in suitable sizes.**

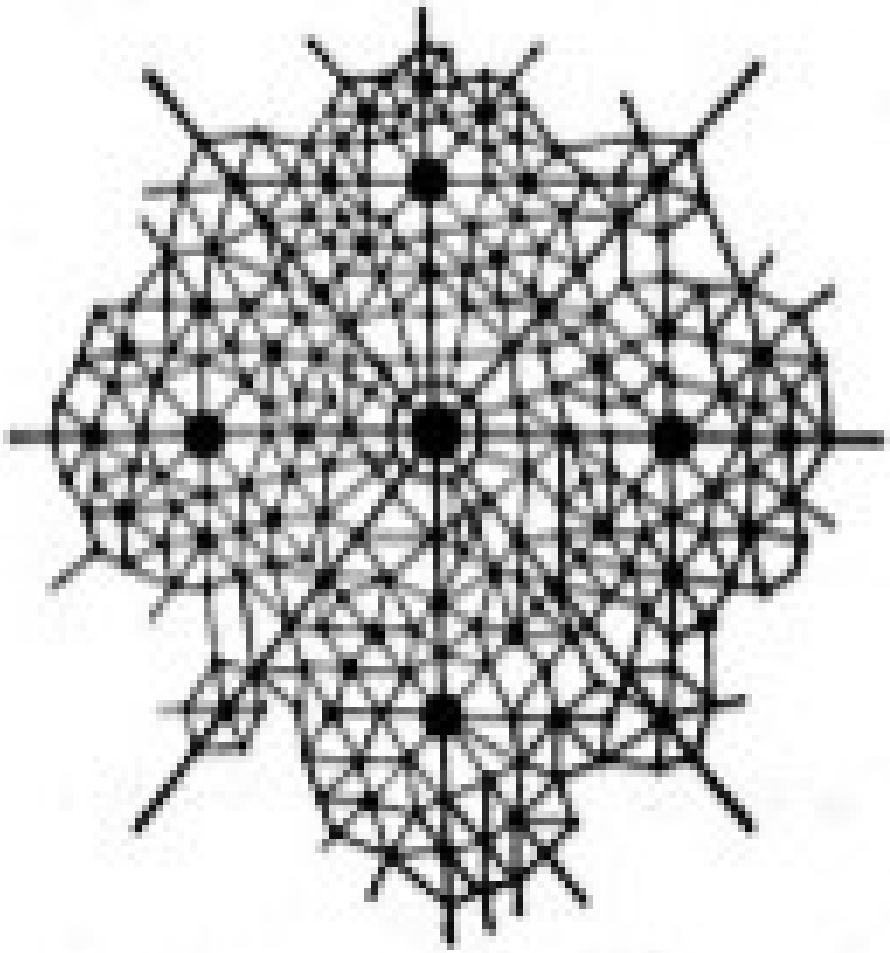
Advantages:

Three roads meet the built-up area boundary by the sides of the hexagons.

Limitations:

Traffic signs, pavement markings, and lighting should be adequate so that drivers are aware that they should reduce their travel speed.

MINIMUM TRAVEL PATTERN



Legend:

City center –

encircled dot-

sector center –

suburban center - *

neighborhood center -

* representation of a Minimum Travel city

MINIMUM TRAVEL PATTERN

- In this road pattern, **city is contented by sector center, suburban center and neighborhood center by the road** which required minimum to connect the city center.

Advantages:

Possible accident spot reduces**.**

Limitations:

1) **Traffic signs, pavement markings, and lighting should be adequate** so that drivers are aware that they should reduce their travel speed.

2) **Intersections can be especially challenging for older drivers.**

Road Authorities in In

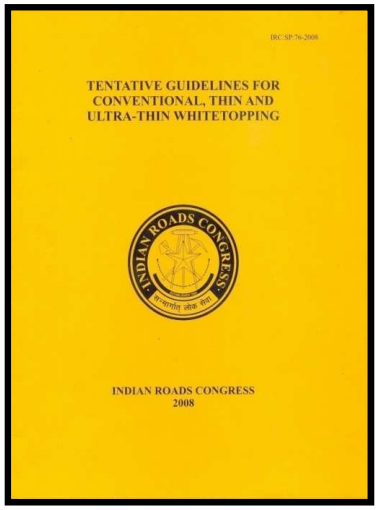
(1) Indian Roads Congress.

- One of the recommendations of Jayakar Committee was establishment of Indian Roads Congress in 1934.

- The inaugural meeting of Indian Roads Congress was held in New Delhi in December, 1934. The meeting was attended by 73 engineers from all parts of India.

The Indian Roads Congress.

- IRC was registered as a society in 1937 under the Societies Registration Act of 1860.
- The principal objectives of IRC are –
- to promote and encourage the science and practice of road building and maintenance.
- to publish standard specifications regarding road and bridge works.
- to hold periodic meetings to discuss technical questions regarding roads and bridges.
- to suggest improved methods of administrations, planning, design, construction, operation, use and maintenance of roads.



(2) Central Road Research Institute (CRRI)

- **Central Road Research Institute (CRRI) is located in Delhi.**
- Established in 1952 as a laboratory of **the Council of Scientific and Industrial Research(CSIR)**.
- It is a Research and Development (R&D) unit which develops technology related to road construction, safer and durable roads.
- It also does R&D in the field of road transportation, highway traffic management, transport planning and all related services like bridges, underpasses etc.
- CRRI also conducts training and development programmes which are developed for various types of professionals
- **Other Activities of CRRI**
    - Arranging the transportation of mega and medium urban areas
    - Administration of streets in various landscapes
    - Change of peripheral materials
    - use of modern waste in street development
    - ground enhancements natural contamination
- This institute also provides consultancy services to various clients in India and abroad.

(3) National Highway Authority of India

- The most remarkable development in the road sector after independence is formation of NHAI.
- NHAI was constituted by an act of Parliament in 1988.
- The authority was operational since February' 1995.
- NHAI has implemented National Highway Development Project (NHDP) since 1998, dividing in several phases.

National Highways Development Project at a glance

NHDP Phase	Particulars	Length	Indicative Cost ₹ (in cr)
NHDP-I & II	Balance work of GQ and EW-NS corridors	13,000 km (8,100 mi)	42,000
NHDP-III	4-laning	10,000 km (6,200 mi)	55,000
NHDP-IV	2-laning	20,000 km (12,000 mi)	25,000
NHDP-V	6-laning of selected stretches	5,000 km (3,100 mi)	17,500
NHDP-VI	Development of expressways	1,000 km (620 mi)	15,000
NHDP-VII	Ring Roads, Bypasses, Grade Separators, Service Roads etc.	700 km (430 mi)	15,000
	Total	45,000 km (28,000 mi)	1,69,500 (Revised to 2,20,000)
Note: 1 crore= 10 million			

Golden Quadrilateral

No.	Segment	Length Completed (km)	Total Length (km)	Percent Completed (%)	As of (date)
1.	Delhi-Kolkata	1,453 km (903 mi)	1,453 km (903 mi)	100	August 31, 2011
2.	Chennai-Mumbai	1,290 km (800 mi)	1,290 km (800 mi)	100	August 31, 2011
3.	Kolkata-Chennai	1,679 km (1,043 mi)	1,684 km (1,046 mi)	99.70	May 31, 2012
4.	Mumbai -Delhi	1,419 km (882 mi)	1,419 km (882 mi)	100	August 31, 2011
Total		**5,841 km (3,629 mi)**	**5,846 km (3,633 mi)**	**99.91**	May 31, 2012

North–South and East–West Corridor

Segment	Total Length	Length Completed	Under Implementation	Length to be Awarded	Percent Completed(%)	As of (date)
North–South & East–West Corridor	7,300 km (4,500 mi)	6,025 km (3,744 mi)	685 km (426 mi)	420 km (260 mi)	84	May 31, 2012

Some pictures of modern road project

Bridge over river Yamuna at Allahabad

Another beautiful bridge- Bandra-Worli Sea link

The man with visionary who was instrumental behind building world class road in India

- Pradhan Mantri Gram Sadak Yojana –PMGSY implemented prime minister of India Sri Atal Bihari Bajpayee from 1998 to 2004.

Pradhan Mantri Gram Sadak Yojana

- PMGSY begun from 25th.December ,2000.
- The target for this project—

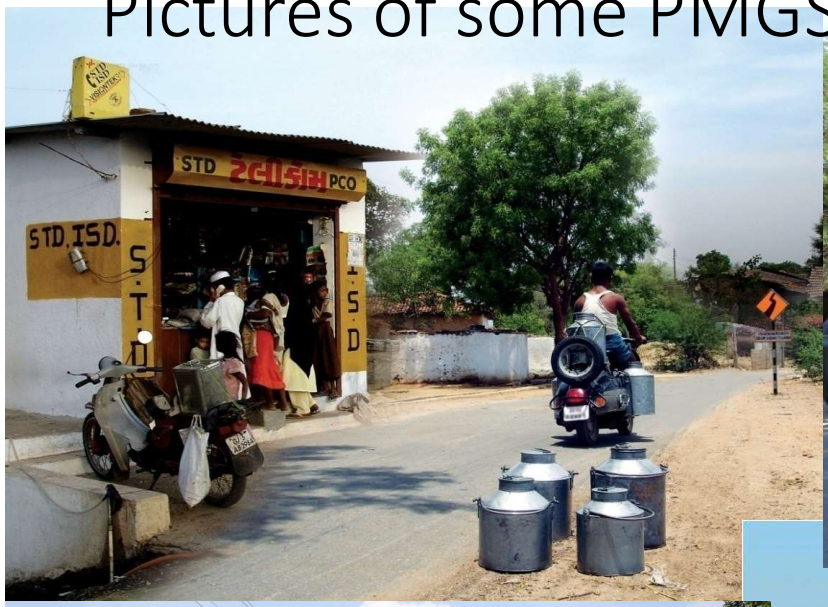
  -- Connectivity for villages with population more than 1000 –by 2003

  -- for villages with population more than 500– by 2007

  -- for villages with population upto 500 – by 2010

- Though there may be some delay in achieving the target, this project had a deep impact on serving the rural population of India and in turn contributing to upliftment of the economy of the country.

Pictures of some PMGSY Roads



Top countries according to total length of road network

Rank	Country	Road length (km)	Expressway length (km)	Date of information
1	United States	6,586,610	77,017	2013
2	India	4,865,000	1,324	2014
3	China	4,460,000	123,000	2016[1]
4	Brazil	1,751,868	11,000	2013
5	Russia	1,396,000	929	2014
6	Japan	1,215,000	8,050	2012
7	Canada	1,042,300	17,000[2]	2013
8	France	1,028,446	11,882	2013
9	Australia	823,217	3,132	2011
10	South Africa	747,014	1,400	2014
11	Spain	683,175	16,583	2013
12	Germany	644,480	12,917	2013
13	Sweden	579,564	2,050	2014[3]
14	Indonesia	496,607	1,710	2014[4]
15	Italy	487,700	6,758	2013
16	Finland	454,000[5]	863	2015
17	Turkey	426,906	2,289 [6]	2010
18	Poland	423,997	3,050[7]	2016
19	United Kingdom	394,428	3,519	2009
20	Mexico	389,345	15,283	2014[8]
21	Pakistan	262,256	2,039	2014 [
22	Argentina	231,374	734	2004
23	Saudi Arabia	221,372	3,891	2006
24	Philippines	217,456	417.6	2016
25	Iran	214,006	2,361	2013[1

Source :Wikipedia, accessed on 26th August ,2016

State wise National Highways In India

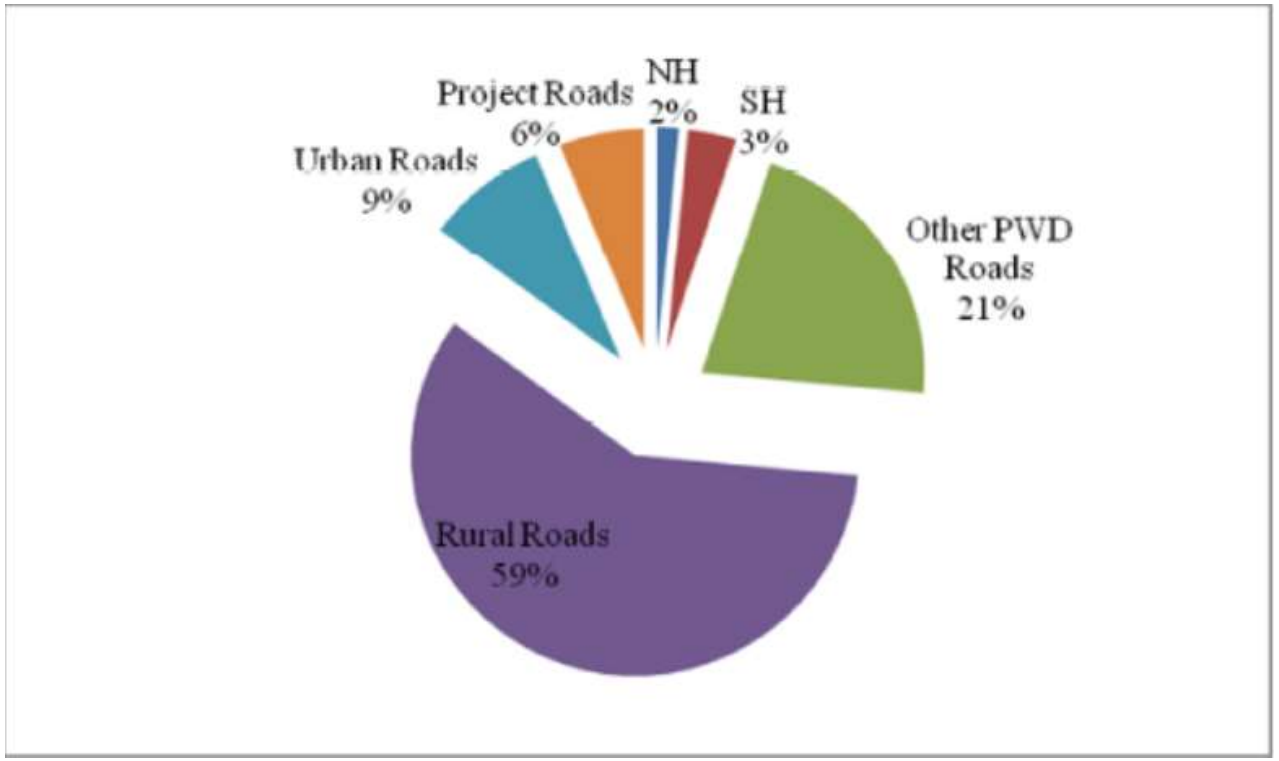
Sl. No.	Name of State	National Highway No.	Total Length (in km)
1	Andhra Pradesh (Seemandhra)	4, 5, 7, 9, 16, 18, 18A, 42 New, 43, 63, 67Ext. New, 150 New,167 New, 202, 205, 214, 214A, 216, 219, 221, 222, 234, 326, 326A, 67 New,71 New, 161 New, 340 New, 340C New, 353 New, 363 New, 365 New, 544D New, 565 New,765 New	5231.74
2	Arunachal Pradesh	52, 52A, 153, 229, 52B Ext, 37 Ext, 315A, 713 New, 513 New, 313 New, 113 New & 713A New	2513.05
3	Assam	6 New, 31, 31B, 31C, 36, 37, 37A, 37E, 38, 39, 44, 51, 52, 52A, 52B, 53, 54, 61, 62, 117A New, 127B New, 127E New, 151,152, 153, 154, 315A New, 127C New & 127D New, 329 New, 427 New, 627 New, 702 New, 702B New, 702C New 702D & 715A New	3811.67
4	Bihar	2, 2C, 19, 28, 28A, 28B, 30, 30A, 31, 57, 57A, 77, 80, 81, 82, 83, 84, 85, 98, 99, 101, 102, 103, 104, 105, 106, 107, 110, 122A New, 131A New, 133 New, 133B New, 219 New, 227 A New, 327A New, 327 Ext. New, 333 New, 333A New, 333B New, 527A New, 527C New, 727 A New & 766C	4678.79
5	Chandigarh	21	15.28
6	Chhattisgarh	6, 12A, 16, 43, 78, 111, 130A New, 130B New, 130C New, 130D New, 149B New, 163A New, 200, 202, 216, 217, 221, 343 New, 930New	3078.40
7	Delhi	1, 2, 8, 10, 24 & 236	80.00
8	Goa	4A, 17, 17A & 17B	262.00
9	Gujarat	NE-I, 6, 8, 8A, 8B, 8D, 8E, 14, 15, 56, 58 New, 58 Ext New, 59, 113 228, 251 New, 753B New, 848 & 848A New, 848B New, 341 New, 68Ext. New, 147A New, 168 New, 168A New, 351 New, 927D New & 953 New	4970.90
10	Haryana	1, 2, 8, 10, 11 New, 21A, 22, 54 New, 64, 65, 71, 71A, 72, 73, 73A , 71B, 148BNew, 236, 248 A New, 254 New, 334B New, 352A, 444A New, 703 New, 709 Ext New, 709A New & NE-II	2622.48
11	Himachal Pradesh	1A, 3 New, 20, 20A, 21, 21A, 22, 70, 72, 72B, 88, 73A , 154A New, 305 New, 503 New, 503A New, 503 Ext. New, 505 New,705 New, 907 A New	2622.48
12	Jammu & Kashmir	1A, 1B, 1C, 1D, 3 New, 144 New, 144A New, 301 New, 444 New, 501 New, 701 New, 244 New	2593.00
13	Jharkhand	2, 6, 23, 31, 32, 33, 43 New, 75, 78, 80, 98, 99, 100, 114A New, 133 New, 133A New, 133B, 143 New, 143A New, 220 New, 333 New, 333A New , 343 New & 419 New	2653.64
14	Karnataka	4, 4A, 7, 9, 13, 17, 48, 50 New, 63, 67, 67New, 150, 150 Ext. New, 150A New, 167 New, 169A New, 173 New, 206, 207,209, 212, 218, 234, 275 New, 367 New, 766C	6502.29
15	Kerala	17, 47, 47A, 47C, 49, 183A New, 185 New, 208, 212, 213, & 220	1811.52
16	Madhya Pradesh	3, 7, 12, 12A, 25, 26, 26A, 26B, 27, 56 New, 59, 59A, 69, 69A, 75, 76, 78, 86, 92, 927A New & 339B	5193.57
17	Maharashtra	3, 4, 4C, 6, 7, 8, 9, 13, 16, 17, 26B, 50, 50New, 69, 150 Ext. New, 161 New, 204, 211, 222, 348 New, 848 New, 160 New, 166 New, 166A New, 348 New, 348A New, 353C New, 353D New, 353E New, 361 New, 363 New, 547E New, 548 New, 753 New, 753A New, 753B New, 848A, 930 New & 953 New, 965 New	7434.79
18	Manipur	39, 53, 102 New, 102A New, 102B New, 102 C New, 129A new, 108A New, 129 New, 137 New, 137A New, 150, 155, 702A New	1745.74

State wise National Highways In India

19	Meghalaya	40, 44, 51, 62 & 127B New	**1204.36**
20	Mizoram	6 New, 44A, 54, 54A, 54B, 102B New, 150, 154, 302 New, 306 A New & 502A New	**1381.00**
21	Nagaland	36, 39, 61, 129 New, 150, 155, 702 New, 702A New & 702B New, 702D	**1150.09**
22	Odisha	5, 5A, 6, 23, 42, 43, 60, 75, 130C New, 153B New, 157 New, 200, 201, 203, 203A, 215, 217, 220 New, 224, 326 New & 326 A New	**4644.52**
23	Puducherry	45A & 66	**64.03**
24	Punjab	1, 1A, 10, 15, 20, 21, 22, 64, 70, 71, 72, 95, 103 A New, 154A, 205A New, 254 New, 344A New, 344B New, 503 Ext. New , 503A New, 703 New 703A New, 754 New & 148B New	**2769.15**
25	Rajasthan	3, 11New, 123 New (3A Old), 8, 11, 11A, 11B, 11C, 12, 14, 15, 25 Ext. New, 54 New, 65, 458 New & 65A Old, 71B, 76, 58 Ext New &76A Old, 758 New & 76B Old, 79, 79A New, 89, 90, 113, 112, 114 , 116,148B New,148D New & 116A Old, 158 New, 162A New, 162 Ext. New, 168 New, 168A New, 248A New, 325 New, 709 Ext. New, 927A New.	**7906.20**
26	Sikkim	31A, 310, 310A New, 510 New, 710 New	**309.00**
27	Tamil Nadu	4, 5, 7, 7A, 45, 45A, 45B, 45C, 46, 47, 47B, 49, 66, 67, 68, 205, 207, 208, 209, 210, 219, 220, 226, 226Ext., 227, 230, 234, 381 New, & 532 New	**5006.14**
28	Tripura	44 , 44A, 108A & 208 New	**577.00**
29	Telangana	7, 9, 16 202 ,221,222,326 New, 167 New, 150 New, 363 New, 365 New, 565 New, 161, 765 New, 50 New, 563 New & 365A New	**2635.84**
30	Uttarakhand	9 new,'58, 72, 72A, 72B,73, 74, 87, 94,107A New, 108, 109, 123, 119, 121 , 125, 309A New, 309B New, 334A & 707A New	**2841.92**
31	Uttar Pradesh	2, 2A, 3, 123 New (3A Old), 7, 11, 12A, 19, 24, 24A, 24B, 25, 25A, 26, 27, 28, 28B, 28C, 29, 56, 56A, 56B, 58, 72A, 73, 74, 75, 76, 86, 87, 91, 91A, 92, 93 ,96, 97 , 119, 219 New, 227 A New, 231, 232, 232A, 233, 235, 330, 330A New, 330 B New, 334B New, 709 A, 727 A New, 730 New, 730A New, 731 A New, 931 New, 931A New & NE-II	**8483.00**
32	West Bengal	2, 2B, 6, 10, 31, 31A, 31C, 31D, 32, 34, 35, 41, 55, 60, 60A, 80, 81, 114A New, 116B New, 117, 131A, 133A New, 317A, 327B, 419 New, 512 New & 717.	**2909.80**
33	Andaman & Nicobar Island	223	**330.70**
34	Dadra Nagar Haveli	848A New	**31.00**
35	Daman & Diu	848B New & 251 New	**22.00**
		Total	**100087.08**

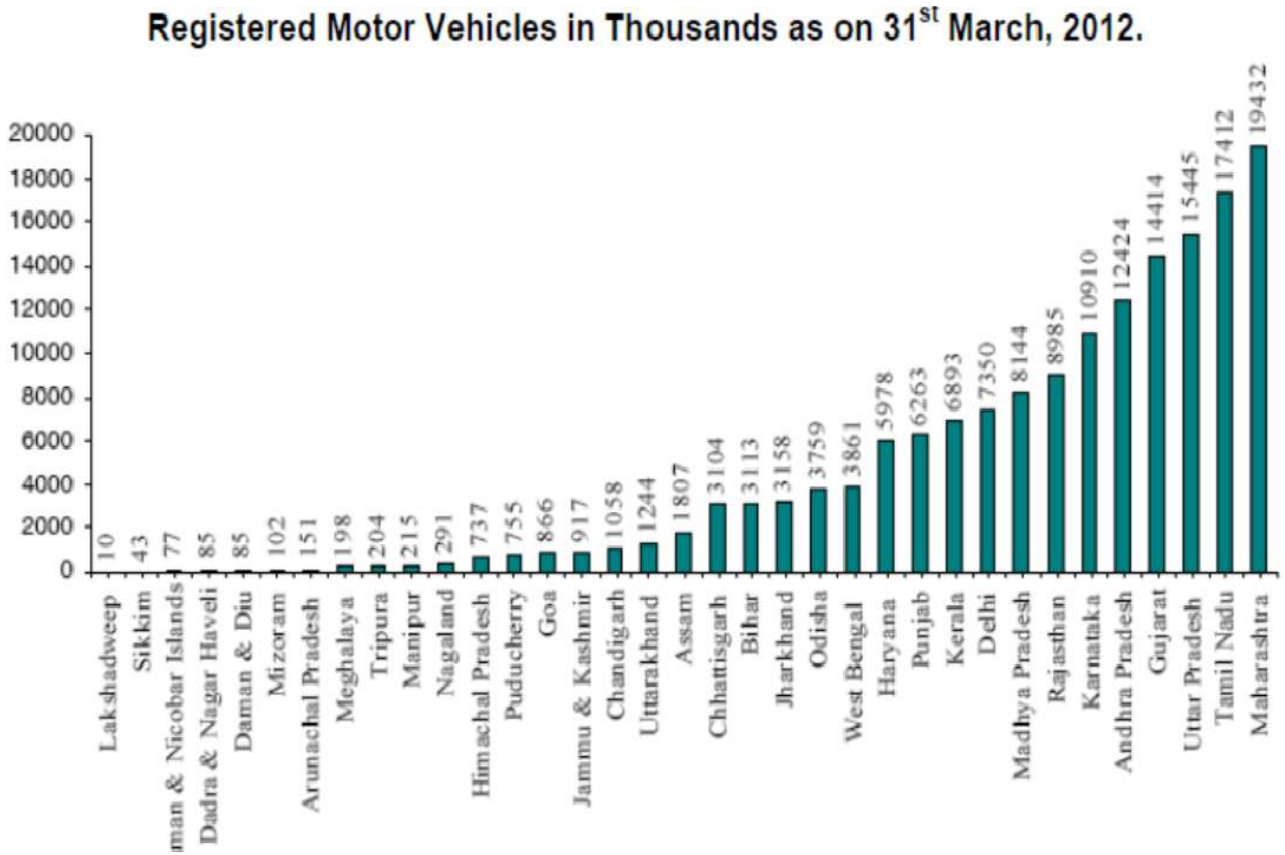
Source: Website of MoRTH accessed on August'2016

Road length by categories

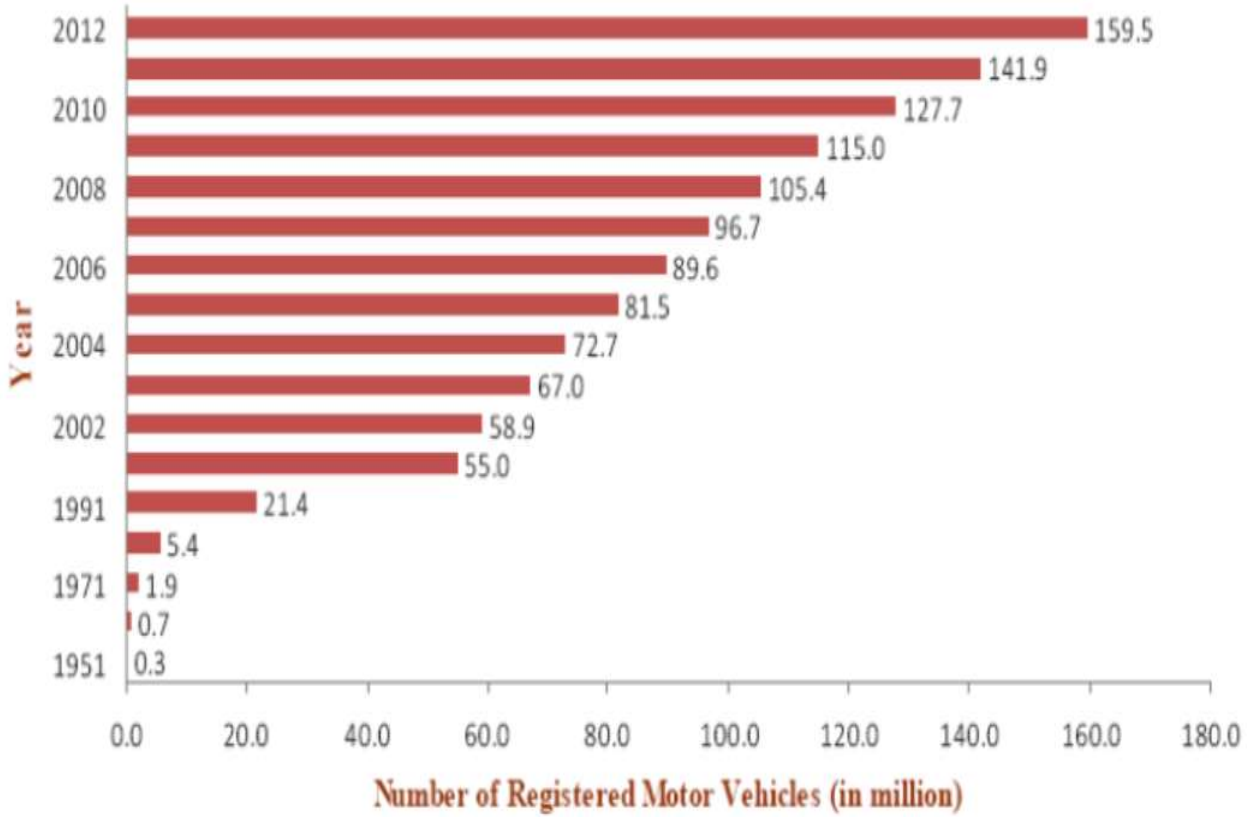


Sources: Basic road statistics of India, MoRTH, August,2012

State wise vehicle population in India



Total vehicle population in India



Financing of road projects

- **Government Funding:** The Indian government, both at the central and state levels, provides a significant portion of the funding for road projects. This funding comes from various sources, including the Union Budget, state budgets, and grants from agencies like the National Highways Authority of India (NHAI) and the Ministry of Road Transport and Highways (MoRTH). The central government's support is particularly important for the development of national highways.

- **Toll Revenue:** Toll collection is a common method of financing road projects in India. Special purpose vehicles (SPVs) are often set up to collect tolls on specific road stretches or expressways. These SPVs are typically responsible for the construction, maintenance, and operation of the roads, and they generate revenue through toll collection. The revenue generated is used for debt servicing and further development.

Financing of road projects

- **External Loans and Funding:** The Indian government may also seek external loans and funding from international financial institutions like the World Bank, Asian Development Bank (ADB), and others. These loans come with favorable terms and conditions and are used to finance road projects, especially those with strategic importance.

- **Public-Private Partnerships (PPPs):** PPPs have gained prominence in financing road projects in India. Under PPP arrangements, private companies or consortiums invest in the construction, operation, and maintenance of roads in exchange for revenue-sharing agreements, typically through toll collection. This approach allows the government to leverage private sector resources and expertise.

Financing of road projects

- **Asset Monetization**: In recent years, the Indian government has explored asset monetization as a means of financing infrastructure projects, including roads. This involves leasing existing road assets, such as national highways, to private entities or through the toll-operate-transfer (TOT) model, where the private entity operates and collects tolls for a specified concession period.

- **Bond Issuance**: State and central government agencies, as well as SPVs, may issue bonds to raise funds for road projects. These bonds are typically tax-free and can attract investments from institutional investors and the public.

Financing of road projects

- **State Budget Allocations:** State governments also allocate funds for the construction and maintenance of state highways and other road infrastructure. These funds may come from the state budget or through grants from central government agencies.

- **Innovative Financing:** In recent years, there has been an emphasis on innovative financing mechanisms such as Infrastructure Investment Trusts (InvITs) and Real Estate Investment Trusts (REITs) to attract investment in road projects.

Financing of road projects

- **Hybrid Annuity Model** (HAM): HAM is a financing model used for highway projects in India, where the government provides a mix of grants and annuities to private developers over the concession period.

- **Green Financing:** To promote sustainable infrastructure, there is a growing emphasis on green financing mechanisms and incorporating eco-friendly practices in road projects.

Road safety audit

- Road Safety Audit (RSA) is **a formal procedure for assessing accident potential and safety performance of new and existing roads**.
- RSA is an efficient, cost effective and proactive approach to improve road safety.
- It is proved that RSA has the potential to save lives.

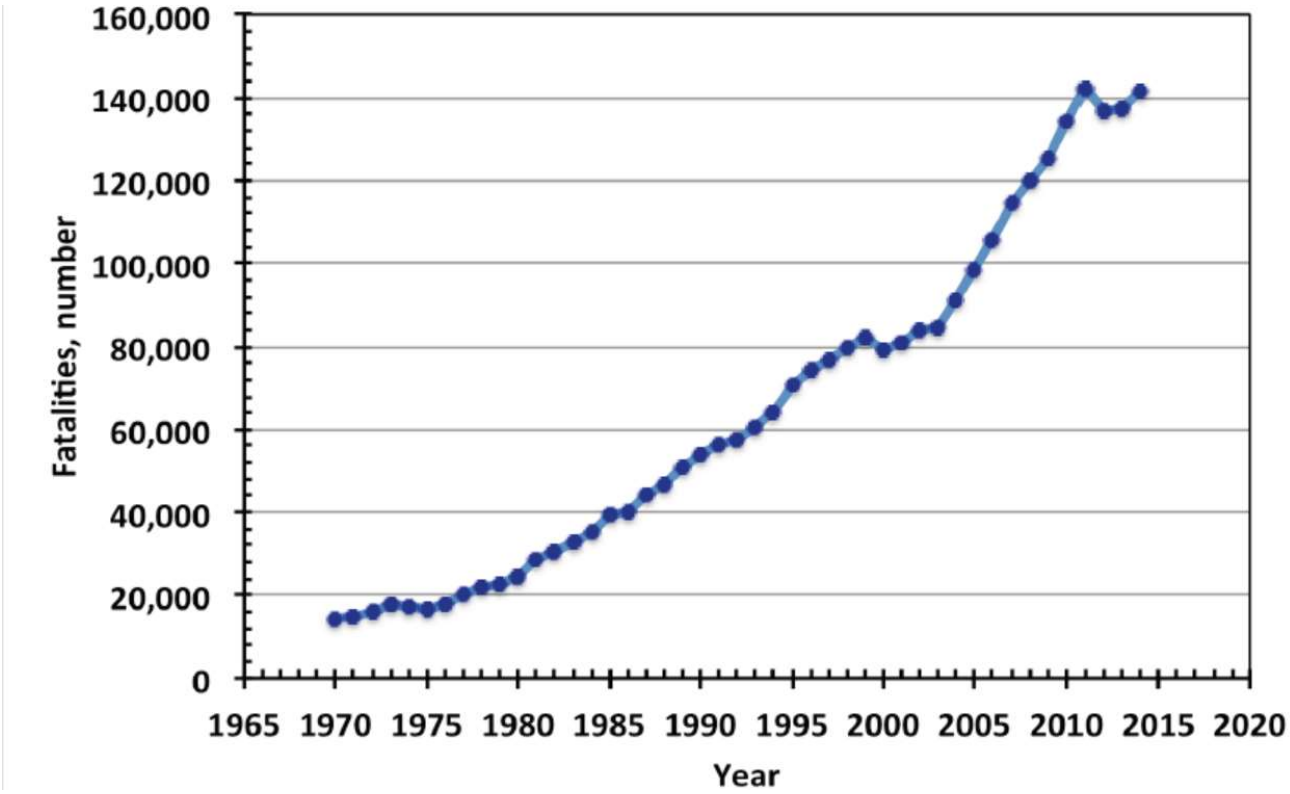
Road Safety Issues

Road accident statistics

Country	Road fatalities per 100,000 inhabitants per year	Road fatalities per 100,000 motor vehicles	Road fatalities per 1 billion vehicle-km	Total fatalities latest year (adjusted/estimated figures by WHO report)
World	17.4			1,250,000
India	16.6	130.1	n/a	238,562

Sources: Wikipedia, List of countries by traffic-related death rate,2013

Road traffic deaths in India 1970 though 2014 (Source: NCRB)



Source: Road safety in India-a status report, TRIPP

Steps to improve road safety

- Education.
- Enforcement.
- Engineering (roads as well as vehicles)
- Emergency care.

Identification & rectification of black spots

- Top black spots identified by 16 states:-
- Andhra Pradesh, Bihar, Chattisgarh, Gujarat, Hariyana, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Nagaland, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal.

- Out of these states, 13 States account for more than 90% of the road accident fatalities.

Research and Development in Highway Sector

- Need for adoption and promotion of new technologies and construction material:
- Need for University Industry interaction with the aim of getting good result of R& D for the end users with a proper mechanism of funding.
- All the implementing agencies like NHAI, NHIDCL, State PWDs, BRO, should be tied up with academic and research institution with proper infrastructure to deliver the need based outcomes.
- The gap between academic and highway professionals should be bridged – should have an attitude to compensate each other – mindset should be changed both ways.

Enforcement of proper Highway Administration

It is desirable to have dedicated administration for Highways which can act with proper enforcement against issues like Overloading, Encroachment, blocking of highway drainage, utility cuts and overhead utilities, unplanned ribbon development etc. , the common causes for early damages of important public asset spread through out the country---highway.

Highway Alignment

- What is alignment?
  - It is the position or layout of the center line of the highway on the ground
  - Horizontal alignment: straight lines, horizontal deviations, and curves
  - Vertical alignment: gradient and vertical curves
- Disadvantages of improper alignment:
  - Increase in construction cost
  - Increase in maintenance cost
  - Increase in vehicle operation cost
  - Increase in accident rate

Highway Alignment – Requirements

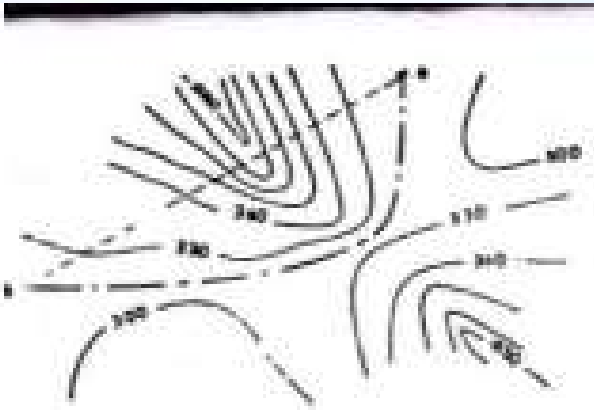
- Basic requirement of ideal alignment between two terminal points
  - Short
  - Easy
  - Safe
  - Economical

Highway Alignment – Factors Controlling Alignment

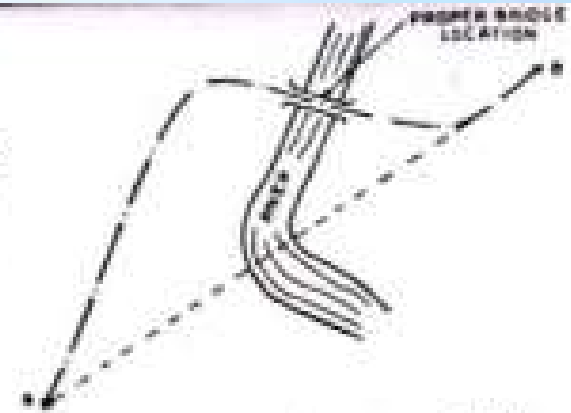
- Obligatory points
- Traffic
- Geometric design
  - Gradient
  - Radius of curve
  - Sight distance, Stopping distance
- Economics
- Other considerations (drainage, political, hydrological)
  - Drainage
  - Stability
  - Geometric standards of hills roads and
  - Resisting length

Highway Alignment – Factors Controlling Alignment

- Obligatory points
  - Obligatory points through which alignment is to pass (bridge site, intermediate town, Mountain pass etc
  - Obligatory points through which alignment should not pass.

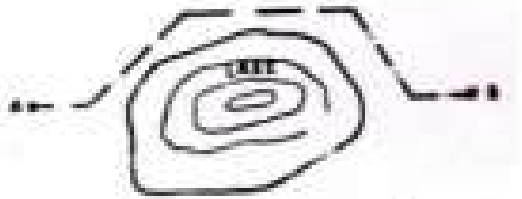


(a) Alignment along a hill side pass



(b) Alignment to suit proper location of bridge

(c) Alignment to connect intermediate town



(d) Alignment avoiding an intermediate area

Engineering Surveys

Before a highway alignment is finalized engineering surveys are carried out. Stages of surveys are:

- Map study
  - Topographic maps – Survey of India has 15 or 30 meter contour maps
  - Alignment avoiding valleys, ponds, or lakes
  - In hilly area possibility of crossing via a mountain pass
  - Approximate location of bridges
  - Alternate alignments are proposed
- Reconnaissance
- Preliminary survey
- Final Location and detailed survey

Engineering Surveys

- Reconnaissance (Second stage)
  - Examine the general character of the area for deciding feasible routes for detailed studies
  - A field survey party may inspect a broad stretch of area
  - Details collected
  - Valleys, ponds, lakes, permanent structures, obstructions
  - Approximate value of gradient, radius of curves of alternate alignments
  - Number and types of crossing drainage structures, flood level
  - Soil types
  - Sources of construction material
  - Geological formations

Engineering Surveys

- Preliminary survey
  - To collect necessary physical information, details of topography, drainage and soil
  - To compare different proposals in view of good alignment
  - To estimate quantity of earth work and other construction aspects to workout cost of alternate alignments
  - To finalize the best alignment
  - Procedure for conventional method of preliminary survey
    - Primary traverse,
    - leveling work - typical cross-sections
    - drainage studies, soil survey, material survey, traffic survey
    - determination of center line
- Final Location and Detailed Survey

Engineering Surveys

- Final Location and Detailed Survey
  - For preparation of plans and construction details
  - Temporary benchmarks are fixed
  - A detailed soil survey is carried out for soil profile
  - Data collected should be elaborate to complete detailed plans, design and estimate of project

Drawings & Reports

- Drawings
  - Key map
  - Index map
  - Preliminary survey plans
  - Detailed plan and longitudinal section
  - Detailed cross-section
  - Land acquisition plans
  - Drawings of cross-drainage and other structures
  - Drawings of road intersections
  - Land plans showing quarries

Project Report

- General details of project and its importance
- Features of the road including selection of route, alignment, traffic
- Road design and specifications
- Drainage facilities and cross-drainage structures
- Materials, labor, and equipment
- Rates
- Construction Programming
- Diversion of roads, traffic control, road side amenities

Part B

- Highway alignment: Basic requirements of an ideal alignment and factors controlling it, special requirements for hill roads
- Field Surveys: Reconnaissance, aerial surveys, location surveys, location of bridges.

Highway Alignment

- The position of the centre line on the highway in the ground is called highway alignment.
- Highway alignment includes horizontal alignment and vertical alignment.
- Alignment must be selected in such a way that the overall cost during construction, operation and maintenance is minimum.

REQUIREMENTS OF HIGHWAY ALIGNMENT

- The ideal alignment must have the following requirements:

Safe (S)

Easy (E)

Short (S)

Economical (E)

Comfort (C)

The requirements can be memorized as **SESEC.**

FACTORS CONTROLLING HIGHWAY ALIGNMENT:

Various factors affecting the alignment of the road are as follows :

- Need of traffic
- Purpose and class of road
- Obligatory points
- Curve
- Gradient
- Sight distance
- Number of drainage crossing
- Railway and river crossing
- Obstruction
- Formation bed
- Earthwork
- Availability of labour and material
- Existing right of way
- Lengthy straight route
- Aesthetical aspect.

FACTORS CONTROLLING HIGHWAY ALIGNMENT:

1) Need of Traffic :

- Alignment should suit need of traffic.
- For fast moving traffic,- straight alignment as possible
- For slow moving traffic (bullock cart etc) - may have sharp bend.

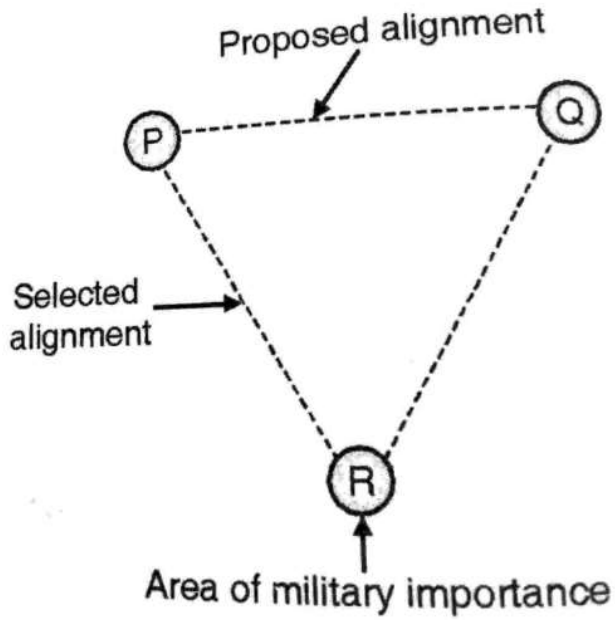
2) Purpose and Class of Road :

- The national highway connecting two important towns should be kept perfectly straight as far as possible.
- On the other hand alignment of other category of road can be deviated when straight alignment is not feasible.

FACTORS CONTROLLING HIGHWAY ALIGNMENT:

- **Obligatory Points**

The alignment should pass through obligatory points such as intermediate important towns, group of villages and area of commercial, political, military and social importance.



Hence to connect obligatory points alignment may be changed.

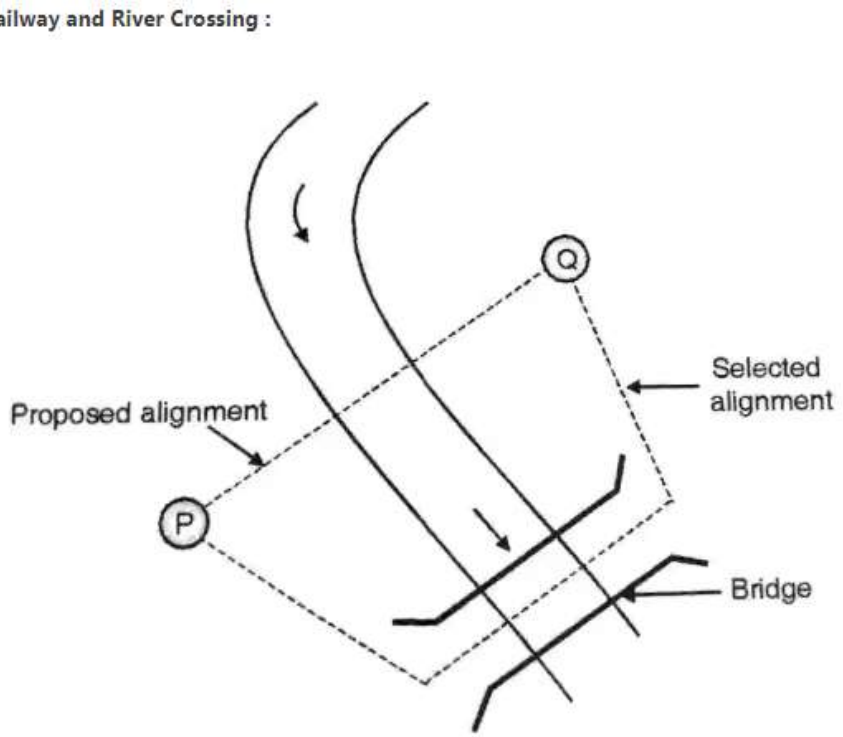
FACTORS CONTROLLING HIGHWAY ALIGNMENT:

- **Curve :** Curves must be as flat as possible. It may be necessary to make adjustment in the horizontal alignment of roads keeping in view the minimum radius of curve and the transition curves.
- **Gradient :** While aligning a new road, the gradient should be flat and less than the ruling or design gradient. Thus in order to avoid excessive fall or rise the alignment is to be changed.
- **Sight Distance :** The minimum sight distance, which should be available in every section of the road, is the safe stopping distance for the fast moving vehicles.
- **Number of Drainage Crossing :** The alignment should have minimum number of drainage crossing. To have maximum number of drainage changes the alignment.

FACTORS CONTROLLING HIGHWAY ALIGNMENT:

- **Railway and River Crossing :**

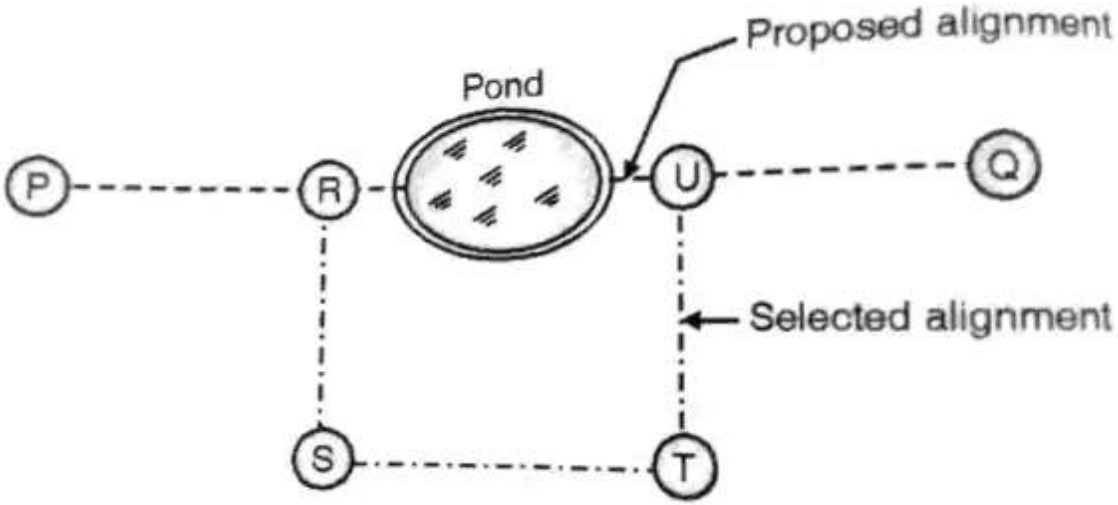
The alignment should cross river or the railway line at right angles. In case of river crossing point, it should fulfil the essential requirements of a good bridge site.



FACTORS CONTROLLING HIGHWAY ALIGNMENT:

- **Obstruction :**

Alignment should be free from obstruction. Hence alignment can be changed to avoid well, lake, pond, historical and religious, buildings etc.



FACTORS CONTROLLING HIGHWAY ALIGNMENT:

- **Formation Bed :** Alignment should run on good soil as far as possible. Hence to fulfill this requirement alignment can be changed.

- **Earthwork :** The alignment should have less earthwork. Hence to avoid excessive cutting or filling, the alignment must be changed.

- **Availability of Labour :** The alignment should provide proximity to labour and material required for the construction of road. Hence to make construction and maintenance of the road economical, alignment of road is changed.

FACTORS CONTROLLING HIGHWAY ALIGNMENT:

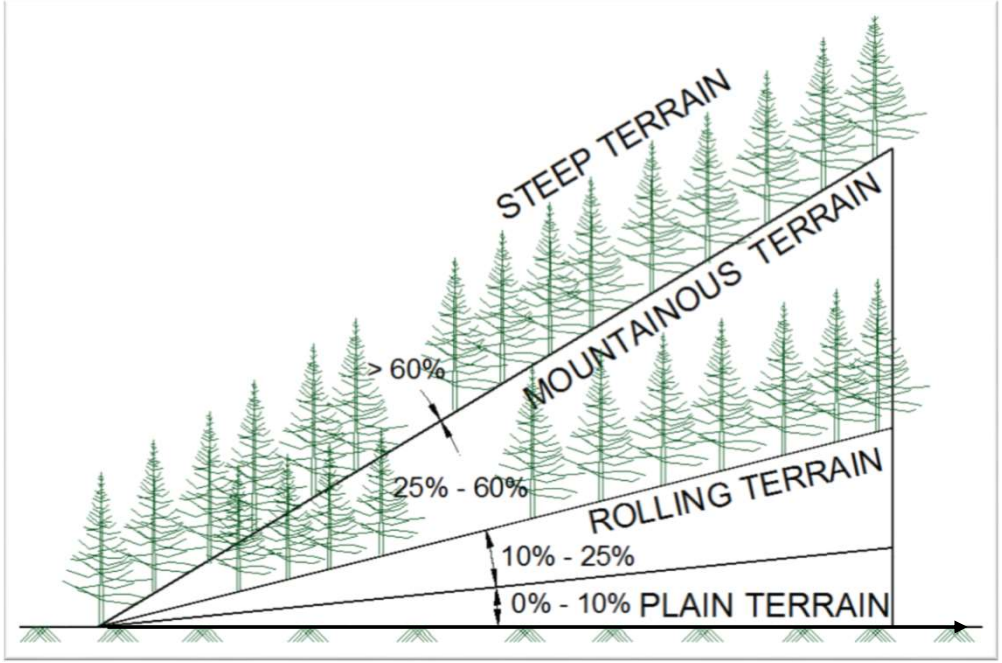
- **Existing Right of Way :** The alignment should make use existing right-of way. Hence to satisfy the requirement, alignment is changed in order to curtail the cost of land acquisition.

- **Lengthy Straight Route :** The alignment should not be monotony caused due to lengthy straight routes. Hence alignment must be have slight bend to break the monotony and to keep the driver alert.

- **Aesthetical Aspect :** The alignment can be changed in order to pass the road through regions of natural beauty and scenery.

Hill Road Alignment

- Hill road is defined as the one which passes through a terrain with a cross slope of 25% or more.



- IRC:SP:73-2015 and IRC:SP:84-2014 have merged the Mountainous and Steep Terrain having Cross Slope more than 25%.

Special Consideration in Hill Road Design

- **Alignment of Hill Roads**
  - .

The designer should attempt to choose a short, easy, economical and safe comforting route

- **General considerations**

- When designing hill roads the route is located along valleys, hill sides and if required over mountain passes.

- Due to complex topography, the length of the route is more.

- In locating the alignment special consideration should be made in respect to the variations in:
  - Temperature
  - Rainfall
  - Atmospheric pressure and winds
  - Geological conditions
  - Resettlement and Rehabilitation considerations
  - Environment Considerations

Field Surveys

- The object of these surveys is to locate the alignment of a road which provides maximum transportation facilities with the minimum cost of construction and maintenance.
- For locating a highway the following engineering or field survey are undertaken.

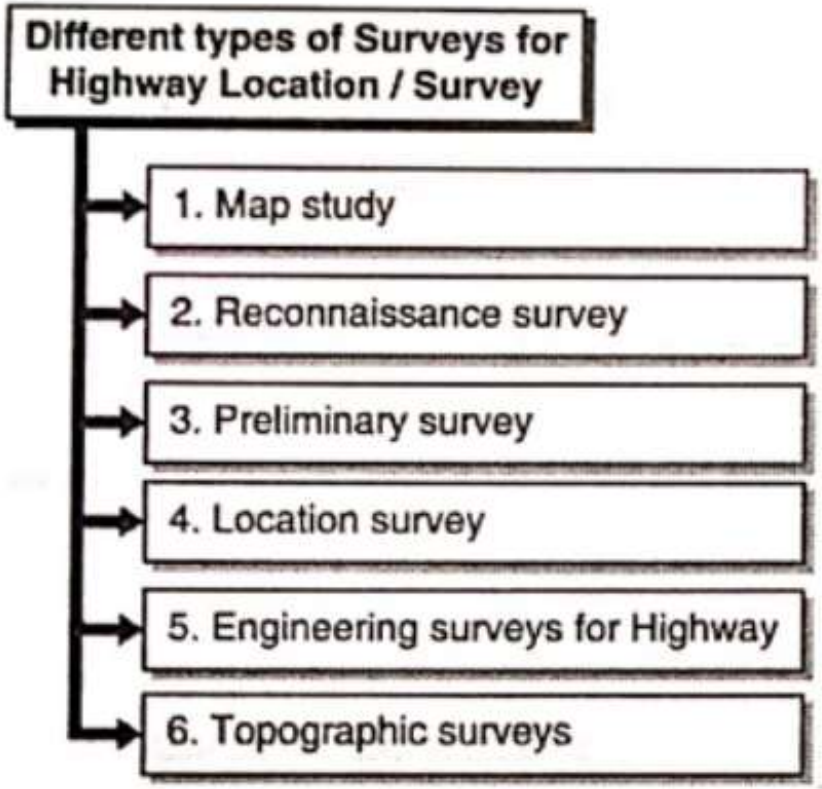


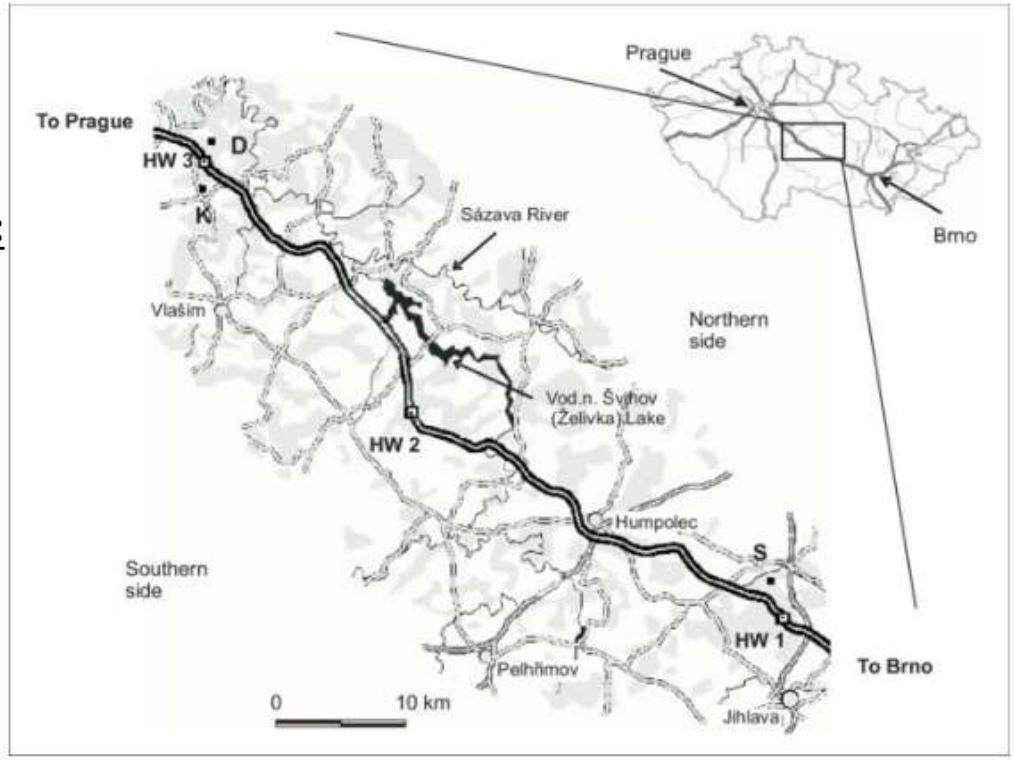
Fig. C1.12 : Different types of surveys for Highway Location / Survey

1. Map study

The study of the topographical map is done to **find out the possible routes of the road**

Following information are obtained from the map study:

- **Alignment avoiding valley, ponds, lakes.**
- **When the road has to carry a row of hills, mountain pass may be the suitable alternative.**
- Approximate location of the bridge site.



2. Reconnaissance survey

- Simple Survey Instruments are used in the reconnaissance procedure.

Following are the information obtained from the reconnaissance survey:

- **Valley, pond, lakes and other features that were not present in the topographical map.**
- **A number of cross drainage structures, High Flood Level (HFL), Natural Ground Level.**
- **Values of the gradient, the length of gradients and radius of the circular curve.**
- **Soil type along the routes from field identification tests and observation of the geological features.**
- **Sources of construction materials.**

3. preliminary survey

- Sophisticated Survey Instruments are used during the preliminary survey.

- Objective of the Preliminary Survey are listed below:
- To collect necessary physical information and details of topography, drainage, and soil.
- To compare different alternative of good alignment.
- To estimate the quantity of earthwork.
- To finalize the best alignment.

- METHODS OF PRELIMINARY SURVEY:
- Conventional Approach
- Modern Rapid Approach

3. Preliminary survey

Conventional Method:

The procedure for the conventional approach are listed below:

- **Traverse:** The traverse is run from the starting point to the end point by setting out various control points. Both primary traverse and secondary traverse may need to be run.
- **Levelling work:** The levelling work is carried out along the centre line or the proposed road. The levelling work is used to estimate the volume of the earthwork. Both L-section and X-section are carried out.
- **Topographical features:** All geographical and man-made features are survey and plotted which are along the traverse and for a certain width on either side.
- **Drainage Studies and Hydrological data:** The number of cross drainage structures are estimated during the preliminary survey.
- **Soil Survey:** The soil survey is conducted in working out details of earthwork, slope, and stability of materials, subsoil and surface drainage requirements and the type of the pavement requirements.
- **Material Survey:** The location of construction materials need to be known.
- **Traffic Survey:** Survey regarding the number of lanes, roadway width, and pavement design need to be done.
- **Determination of final centre line:** After completion of all the above mention steps and calculating the amount of earthwork, the final centre line is determined.

3. Preliminary survey

Modern rapid approach:

The procedure of the Modern rapid approach are listed below as:

- Taking aerial photographs with required lateral and longitudinal overlaps.
- These photographs are then examined under stereoscopes and control points are selected for the establishment of the traverse.
- The spot levels and contour lines may be obtained from the stereo – pair observations.
- Photo interpretation method is used to grab information on the geological features, soil conditions, drainage requirement, etc.

4. Location Survey

- *The detailed examination of the field along the alignment finally recommended during the preliminary survey is called* ***Location survey***.
- In this survey instruments used are theodolite, level, plane table, tape, etc.

4. Location Survey

OBJECTS

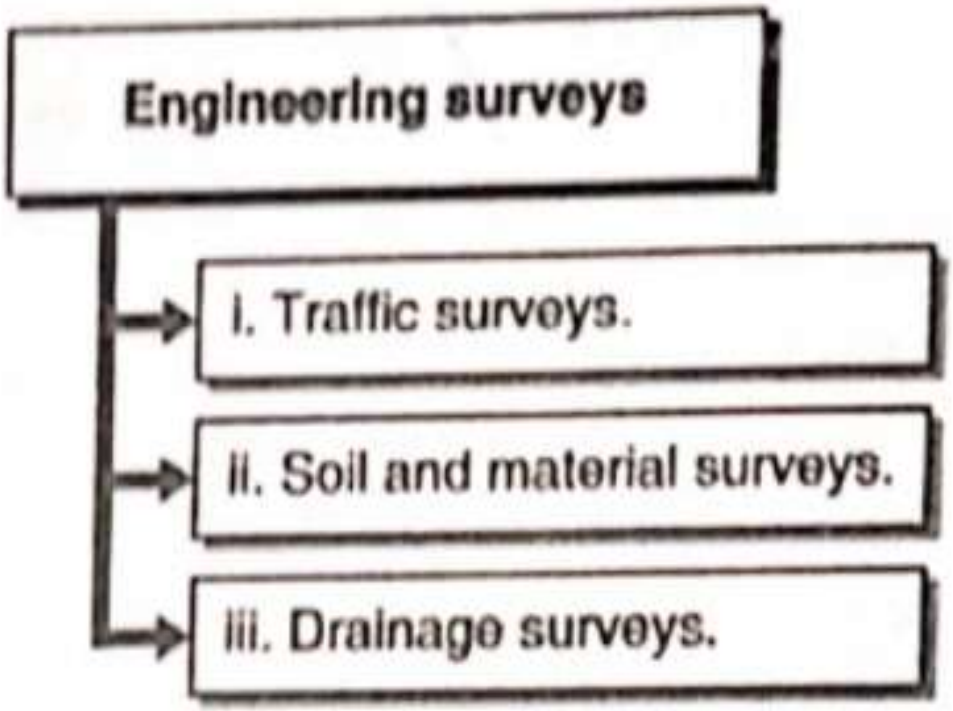
(i) To first locate the centre line of the alignment of best road

(ii) To collect the information necessary for the preparation of plans and construction details for the highway project.

(iii) To determine the cost of the total road project.

5. Engineering Surveys for Highway

- When the **selection of final alignment or final centre line is done with the help of a planning survey, the next part is to perform an engineering survey**.
- Engineering surveys consists of three surveys to be carried out as follows.



5. Engineering Surveys for Highway

(i) Traffic surveys

- In the case of a highway project, the detail information of traffic is much necessary so as to design the road pavement, fixing the number of traffic lanes, geometric design of roads and other economical aspects.
- Traffic surveys are started from simple traffic counts to detail of traffic nature and transportation studies.
- Various studies like speed studies, traffic volume studies, delays, journey time are more essential to carry out for the purpose of road design and also improvement of existing road network.

5. Engineering Surveys for Highway

(ii) Soil and material surveys

- Soil and material surveys are many important surveys since the earth work related with respect to the major portion of the road cost.
- Detailed information on various classifications of soils is collected and various field tests and laboratory test are being carried out for the purpose of their suitability for embankments.
- Materials such as road aggregates, bitumen, tar cement concrete, and any other required for the construction of the road.
- Material survey is also carried out in which its suitability, durability, availability has prime importance and varies laboratory test on-road materials are also being carried out

5. Engineering Surveys for Highway

(iii) Drainage surveys

- Drainage surveys are required mainly for the purpose of design of cross drainage structure and survey on drainage is quite useful in fixing the gradient or grade line of the road.
- Information about high flood level (HFL), depth of water table, rainfall intensity, etc is being collected.
- Proper drainage surveys are helpful in the good design of the surface drainage system

6. Topographic surveys

- Topographic surveys consist of determining the horizontal and vertical locations of objects on the surface of the earth.
- Topographic surveys show the nature of the ground or profile of ground which is the most essential part for proper road alignment.

Part C

- C. Highway Geometric Design: Topography and physical features, cross section elements like carriageway width, formation width, right of way, etc., friction, Light reflecting characteristics, roughness, camber, sight distances, horizontal alignment, design speed, super-elevation, transition curve, gradients.